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Flow-of-Funds Social Accounts for the Farm Sector*

John B. Penson, Jr., David A. Lins, and George D. Irwin

Flow-of-funds accounts and component sources-and-uses-of-funds statements relate changes in balance sheet accounts to income statements, describing movement from one balance sheet to the next. While the Federal Reserve System compiles a *farm business sector* sources-and-uses-of-funds statement consistent with and part of the national flow-of-funds accounts, the statement is not definitionally and conceptually consistent with published farm income and balance sheet accounts. An alternative *farm sector* sources-and-uses-of-funds statement is proposed that contains these features, and its potential applications and extensions are delineated.

Policy and predictive questions facing agricultural economists today increasingly involve a financial dimension. These questions require analysts to relate farm income streams and other sources of funds to changes in balance sheet items. Often comparisons are needed on a sector or subsector basis as well as for national aggregates. We suggest that few agricultural economists are familiar with social accounts that treat financial questions involving distinct sectors—the flow-of-funds social accounts.

The basic purposes of this article are: (1) to bring attention of agricultural economists to the concepts of flow-of-funds accounting, including the sector sources-and-uses-of-funds statement, with the hope of stimulating professional interest; (2) to present a sources-and-uses-of-funds statement for the farm sector corresponding to the sector definitions employed in the USDA farm income and balance sheet accounts; (3) to illustrate briefly how the flow-of-funds matrix and its component sources-and-uses-of-funds statement provide additional useful insights into the functioning of the farm economy; and (4) to touch on various ways that expansion of the accounts could more meaningfully describe relevant relationships in an increasingly integrated economy.

The Rationale of Flow-of-Funds Accounts

One of the major purposes of a national accounting system is to help piece together a variety of statistical information as an aid in analyzing structural and operational aspects of the economy. As one of the more recently developed systems, "the flow-of-funds accounts . . . . are as indispensible for understanding developments and interrelationships in financial markets as the national income accounts are for understanding trends in production and real output" [13, p. 4].

Concepts of the accounts

Copeland conducted much of the pioneering work in the field, constructing what were then known as money flows [4]. The Federal Reserve System (FRB) began in 1948 to define and construct a national flow-of-funds (FOF) matrix that could be updated on a regular basis. These efforts resulted in an initial set of accounts encompassing the 1939–53 period. They were updated quarterly and are now based on technique revisions made in 1959 and 1962 [2, 3]. One basic generalization from Copeland's approach was the shift from measuring money flows alone to measuring flows involving all financial transactions. Money remains the unit of account, but the change in holdings of money is only one component of the financial transactions that are measured.

The central idea of constructing flow-of-funds accounts can be described mechanistically in three simple steps: divide the economy into sectors; develop a sources-and-uses-of-funds (SAUF) statement of all financial transactions for each sector; place them side by side to get a FOF matrix.[1] The difficulties come when attempting to implement the procedures in a way that is both theoretically and empirically meaningful. This involves defining unique sectors (transactors) and sources and uses (transactions). These definitions may be conditioned by the availability of data with which to estimate flows.

* Helpful comments on an earlier draft from C. B. Baker of the University of Illinois, John E. Lee, Jr., and Allen Smith of the Farm Production Economics Division, ERS, USDA, and Stanley Sigel of the Federal Reserve System are greatly appreciated. The views and conclusions are the author's and are not to be attributed to the U.S. Department of Agriculture.

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[1] Financial transactions may be identified by the fact that an asset owned by one transactor exists as a liability on the balance sheet of another party. Taken together, financial assets and liabilities offset each other for the economy as a whole.

Analysis of the accounts

An FOF matrix can be viewed as an ex post record of the flows through which the supply and demand for financial assets are equilibrated. The accounts aid in tracing through the process by which purchases of real assets are financed, as well as in studying the volume and content of purely financial activities. Duesenberry [4, p. 180] points out, however, that FOF accounts do not in themselves reveal the implications behind the financial interactions but rather record the results of these interactions. To gain an understanding of the financial process, one would have to examine more than one FOF matrix with the knowledge of what "shocked" the economy between the two periods in question. Thus, in addition to their descriptive function, the accounts can serve as data for econometric models designed to measure and test relationships. Tobin [4, p. 190] suggests that an explanation of the basic behavior behind FOF analysis requires examining the flows, considered as adjustments of individual balance sheets, toward a desired allocation of asset and debt holdings between successive time periods.

The accounts for a single sector (SAUF statement) may be examined or even estimated separately. The sector SAUF statement (and hence the overall FOF matrix) is an accounting system that combines features of a given sector's income statement with balance sheet changes. Our analysis will be concerned with (1) describing a currently available SAUF statement for the *farm business* sector, (2) constructing an alternative *farm* sector SAUF statement to allow direct comparisons with the *Balance Sheet of the Farming Sector* (*BSFS*) and *Farm Income Situation* (*FIS*), and (3) suggesting ways in which the SAUF statement approach can be used to improve our data for understanding the farm economy.

The Farm Business Sector SAUF Statement

FRB flow-of-funds accounts have been developed on a farm business sector basis, whereas most of us think in terms of an aggregate of firm-household units as a farm sector.[2] The former excludes personal and household activities of farm operators; the latter attempts to include most of them. The FRB uses income data supplied directly by the U.S. Commerce Department. The farm portion of these data is originated by the USDA with coverage modified by the Commerce Department to maintain consistency in their accounts. The FRB accepts the conventions inherent in the Commerce Department's farm business sector definition and adds assumptions of its own in deriving the farm business SAUF statement. Certain asset and debt data from the *BSFS* are also utilized.

On the basis that sources of funds (*SF*) must equal uses of funds (*UF*), categories of sources and uses are defined to isolate unique characteristics of the various flows. Certain conventions are followed in identifying particular flows as either source or use. If the flow is opposite to that implied by the accepted convention, it is entered as a negative value on the "conventional" side of the statement. Most of the figures reported are net change, though (as we suggest later) whenever data become available, gross flows are often much more revealing.

The FRB farm business sector SAUF statement may be summarized as follows:[3]

$$(1.1)\qquad UF = \sum_{i=1}^{N} (CE_i + \Delta FA_i)$$

where

$$\Delta FA = \sum_{i=1}^{N} (\Delta DDC_i + \Delta NLIC_i)$$

and

$$(1.2)\qquad SF = \sum_{i=1}^{N} (CC_i + RCE_i + NFY_i - PYW_i)$$

subject to

$$\sum_{i=1}^{N} (NFY_i - PYW_i) = 0.$$

[2] This difference in sectoral definition is also found in comparing national with farm balance sheet accounts and in comparing national with farm sector income accounts. For example, the USDA prepares farm income and balance sheet accounts for the farm sector, which includes aspects of operator households. The U.S. Department of Commerce aggregates the income data differently, splitting the totals to put part in a farm business sector and part in a consumer sector.

[3] Glossary of terms:
- CE = Capital expenditures plus net changes in inventories of current production.
- CC = Capital consumption.
- RCE = Retained earnings of farm corporations.
- ΔFA = Net change in financial assets.
- ΔCMI = Net change in credit market instruments.
- ΔTD = Net change in trade debt.
- PNI = Proprietor net investment.
- NFY = Net farm income.
- PYW = Proprietor income withdrawals.
- ΔDDC = Net change in demand deposits and currency.
- $\Delta NLIC$ = Net change in non-life insurance claims.
- N = Number of farm business enterprise units.

A crucial assumption made by the FRB is that all current net income is withdrawn from the farm business sector by noncorporate proprietors to the household sector. Proprietor net investment (PNI) is then calculated residually —whatever amount is necessary to equate sources and uses of funds. Given (1.1) and (1.2), one can solve the system for PNI:

$$PNI = \sum_{i=1}^{N} (CE_i + \Delta FA_i) - \sum_{i=1}^{N} (CC_i + RCE_i + \Delta CMI_i + \Delta TD_i) \tag{1.3}$$

One of the consequences of using these procedures will illustrate the kinds of interpretation problems they pose in relating to the USDA income and balance sheet series. The FRB farm business sector SAUF statement shows proprietors disinvesting in agriculture while the *BSFS* shows proprietors' equities rising from $178.6 billion in 1960 to $243.4 billion in 1969 [14]. This seeming contradiction arises for three reasons. First and most important for our immediate purposes, unrealized capital gains are a source of proprietors' equities in the *BSFS*, based on current market evaluation of real assets. The FRB farm business sector SAUF statement, on the other hand, records only actual transactions. Thus, capital gains are not recorded in the FRB account until they are realized. Changes in farm mortgage debt holdings are recorded, however, in the form of changes in outstanding credit market instruments. The question is: Should one assume a flow is created by unrealized capital appreciation? If so, should this form of investment be entered at full value or deflated by perhaps the rate of inflation? Second, the FRB farm business sector SAUF statement separates the household and business activities of the proprietor-family enterprise, assuming that all net farm income is withdrawn by the household and excluding farm family assets and income other than those attributable directly to farming. The *BSFS* does not make this distinction. It includes information on many of the financial assets of the "farm operator" residing on a "physical site," using this data to compute "proprietors' equities." Thus, one faces the problems of defining what the relative scope should be when constructing such accounts and of understanding clearly what is assumed when using preexisting sets of accounts. Third, the FRB farm business sector SAUF statement residually measures *proprietor* capital and financial investment in nonappreciable assets. The *BSFS* measures stocks of capital and financial investment in *all* real goods, from farm and nonfarm sources. Thus, one cannot com- compare these two existing accounts without making allowances for the differences in conceptual constructs.

Various definitional inconsistencies between the FRB farm business sector SAUF statement and the farm income and balance sheet series published by the USDA also impede inter-account comparisons. A semantics problem arises when two accounts contain the same figure but their nomenclature differs. For instance, "bank loans" in the FRB farm business sector SAUF statement includes the same items as "non-real estate debt of all reporting banks" in the *BSFS*. Discrepancies also occur when an item given the same name is defined differently in the two accounts. For example, the FRB account defines the "net increase in financial assets" to include net changes in demand deposits, currency, and non-life insurance company claims. The *BSFS*, on the other hand, defines the same item to include time deposits, demand deposits, currency, U.S. savings bonds, and investments in cooperatives, while excluding non-life insurance company claims. Which definition is appropriate depends, of course, on the scope, orientation, and use to be made of the estimates.

Alternative Farm Sector SAUF Statement

Past examination of social accounting techniques employed for the farm sector have shed considerable light on how the sector social accounts can be misinterpreted. The recent controversy over the "realized" farm income concept serves as one example [5, 7, 8, 11]. Irwin [9], in exposing three myths associated with the *Balance Sheet of Agriculture*,[4] suggested that reexamination of data series needs and orientation be a constant activity if we are to be able to measure the changing financial structure of the farm sector. Confronted by the potential usefulness[5] of FOF analysis but the lack of direct comparability between the FRB farm business

[4] The *Balance Sheet of Agriculture* has recently been renamed the *Balance Sheet of the Farming Sector* to clarify, among other things, the exclusion of related agribusiness firms from the account.

[5] In a later section we amplify on these uses. In order to do so, it is helpful to have estimates before us. We thus deviate for pedagogical reasons from the logical order in which the need is demonstrated before the work is done.

sector SAUF statement and existing farm sector social accounts, we have attempted to create a farm sector SAUF statement directly consistent with the USDA balance sheet and income series.

We are not suggesting changes in the FRB account since to do so would destroy its comparability with other sectors within the national FOF matrix. An alternative SAUF statement is needed that would capture the above points and be internally consistent with existing farm sector social accounts. Admittedly, growing involvement of farm operators in nonfarm activities (and vice versa) is creating interpretation problems. Our purpose here is not to make a case for either redefining or recognizing a change in the identity of the farm sector, but merely to adapt the SAUF statement to existing series. Ideally, one should be able to bridge from it to the FRB account whenever the analysis requires.

Again, given that sources of funds equal uses of funds for the sector, our suggested alternative SAUF statement for the *farm* sector is as follows:[6]

$$UF = \sum_{i=1}^{M}(NCE_i + \Delta I_i + IRE_i + \Delta FA_i) + PW \tag{2.1}$$

where

$$\Delta FA = \sum_{i=1}^{M}(\Delta DTC_i + \Delta GS_i + \Delta IC_i)$$

and

$$SF = \sum_{i=1}^{M}(CC_i + NFY_i + OFY_i + \Delta RED_i + \Delta NRED_i + CA_i) \tag{2.2}$$

Setting sources of funds equal to uses and solving this time for proprietor withdrawals (PW) residually:

$$PW = \sum_{i=1}^{M}(CC_i + NFY_i + OFY_i + \Delta RED_i + \Delta NRED_i + CA_i) - \sum_{i=1}^{M}(CE_i + \Delta I_i + IRE_i + \Delta FA_i) \tag{2.3}$$

Three changes are apparent in a comparison of equations (1.3) and (2.3). First, the alternative account measures withdrawals by the proprietor-family enterprise as a residual. Second, the alternative account treats nonfarm income as earnings, implying that the decision to work off the farm is a conscious decision about the use of farm resources, designed to enhance the overall earning power of the unit. Third, the alternative account includes capital appreciation as a source of funds. Capital appreciation is also a use of funds, being summed with capital expenditures on real estate assets to derive total investment in real estate assets (IRE).

The FRB account excludes almost all nonfarm activity, although conceptually sectors are supposed to be defined on an institutional rather than activity basis (see Ruggles [4, p. 93] and FRB [1, p. I. 34]. Though it certainly is an important issue, we do not wish to argue the merits of an activity-based account versus one that is a hybrid leaning toward the historic family farm institution. Our purpose is merely to attain comparability.

Conceptually, proprietor withdrawals may contain income, capital, and financial withdrawals by the proprietor-family enterprise unit. It is assumed that the net increase in financial assets are financial investments by the farm sector in other sectors of the economy. Proprietor capital investment (CI) in the farm sector is thus defined as net farm income and nonfarm income plus appreciation less proprietor withdrawals and financial investment in other sectors. Or stated another way:

$$CI = \sum_{i=1}^{M}(NFY_i + OFY_i + CA_i) - PW - \sum_{i=1}^{M}(\Delta FA_i) \tag{3.1}$$

If, for example, $PW + \Delta FA > NFY + OFY + CA_i$, proprietors have made a capital disinvestment

[6] Glossary of additional variable names:
PW = proprietor withdrawals.
OFY = nonfarm income of farm family.
IRE = total investment in real estate assets (includes appreciation gains).
ΔGS = net change in government security holdings.
ΔIC = net change in investment in cooperatives.
ΔRED = net change in real estate debt.
$\Delta NRED$ = net change in non-real estate debt.
ΔFA = net change in financial assets.
ΔI = net change in inventories of current production.
M = number of proprietor-family units.
ΔDTC = net change in demand deposits, time deposits, and currency.
NCE = non-real estate capital expenditure.
CA = capital gains in real assets.

in the farm sector. A capital disinvestment could be financed by increased debt as reflected in ΔRED and/or $\Delta NRED$, or alternatively, the result of capital depreciation of real assets.

Implicit in the above formulation is the assumption that all increases in *RED* and *NRED* represent investment by nonfarm sources in the farm sector. This assumption would be violated, for example, in the case of land sales financed by sellers, but only when a seller remains an active participant in the farm sector. The result is that our assumption leads to an overstatement of nonsector investment in the farm sector and a corresponding understatement of proprietor investment in the farm sector. The degree of overstatement of investment in the farm sector by nonfarm sources depends primarily upon the importance of active farmer-seller financing.

Empirical Application

Summaries of the FRB farm business sector SAUF statement and the alternative farm sector SAUF statement for 1967 are presented in Tables 1 and 2, respectively. The most important general result is found when comparing proprietor net investment with proprietor withdrawal. Proprietor net investment (*PNI*) of minus \$3.5 billion represents a net capital and financial disinvestment from the farm business sector. Proprietor withdrawals (*PW*) in Table 2 include income, capital, and financial withdrawals by the proprietor-family enterprise unit from the *farm* sector of \$28.1 billion. Employing formula (3.1), proprietor capital investment in the farm sector is \$6.1 billion, substantially higher than the amount reported in the FRB account.

Given the assumptions implicit in equation (3.1), one can calculate the total capital investment in the farm sector *from all sources* by summing proprietor capital investment and the net increase in *RED* and *NRED*. The calculation of total capital investment in the farm sector based on data in Table 2 need not correspond to the increase in physical assets in the *BSFS*. Inventory items in the *BSFS* are based on year-end prices, whereas inventories in the farm income statement are based on average prices for the year. One could make Table 2 consistent with the *BSFS* by replacing capital expenditures, capital consumption, and change in inventories with the net change in "non-real estate assets" figure in the *BSFS*.

One can reconcile the \$9.6 billion difference (\$6.1 − (−\$3.5)) between the proprietor capital

Table 1. Federal Reserve farm business sector sources-and-uses-of-funds statement, United States, 1967[a]

Transaction category	Uses of funds[b]	Sources of funds[b]
	billion dollars	
Current account		
Nonfinancial transactions		
1. Net farm income		14.4
2. Proprietor income withdrawal	14.4	—
3. Net saving of noncorporate businesses		0.0
4. Retained earnings of farm corporation		0.1
5. Capital consumption		5.7
6. Current surplus = gross saving		5.8
Capital account		
Nonfinancial transactions		
7. Gross investment	5.8	
8. Capital expenditures	6.6	
9. Residential construction	(0.6)	
10. Plant and equipment	(5.5)	
11. Change in inventory	(0.5)	
Financial transactions		
12. Net financial investment	−0.8	
13. Net increase in financial assets	0.3	
14. Net increase in liabilities		1.1
15. Credit market instruments		3.1
16. Mortgages		(1.8)
17. Bank notes		(0.7)
18. Other loans		(0.6)
19. Trade debt		1.5
20. Proprietor net investment		−3.5

[a] Adapted from unpublished data of the Federal Reserve System.
[b] Data used by the FRB are supplied directly by the U.S. Department of Commerce. Several items differ from USDA figures because of adjustment for sectoral definition.

and financial investment in the FRB farm business sector SAUF statement and proprietor capital investment in our alternative farm sector SAUF statement as follows:

(1) \$9.9 billion difference due to the inclusion of appreciation in real estate assets in the alternative account;

(2) \$0.3 billion difference due to the different interpretations of the net increase in financial assets;

(3) \$0.1 billion difference in the measurement of the net increase in debt; and

(4) \$0.1 billion difference due to the inclusion of retained corporate earnings (*RCE*) in the FRB account, an item that is consolidated with net farm income in the alternative account.

For 1967, items (3) and (4) cancel each other, leaving items (1) and (2) to account for the \$9.6 difference between the two statements.

Table 2. Alternative farm sector sources-and-uses-of-funds statement, United States, 1967.[a]

	billion dollars	
Sources of funds		
1. Net farm income[b]	14.6	
2. Nonfarm income	10.7	
3. Capital consumption	5.7	
4. Net change in real estate debt	2.2	
5. Net change in non-real estate debt	2.5	
6. Capital appreciation of real estate assets	9.9	
Total sources of funds	45.6	
Uses of funds		
7. Total capital expenditures	6.1	
8. Net change in farm inventories[c]	0.5	
9. Net change in financial assets	1.0	
10. Net change in deposits and currency		(0.6)
11. Net change in U.S. savings bonds		(−0.1)
12. Net change in investment in cooperatives		(0.5)
13. Total investment in real estate assets	11.2	
Subtotal	17.5	
14. Proprietor withdrawals	28.1	
Total uses of funds	45.6	

[a] Items 1, 2, 3, 7, and 8 were taken directly from the 1968 *FIS*. Items 4, 5, 6, 9, 10, 11, 12, and 13 were taken directly from the 1968 *BSA*.
[b] Includes income from corporate and noncorporate enterprise units.
[c] Not classified as a capital expenditure because the farm business and the household unit were treated as one.

Potentials and Directions

These estimates represent a first attempt to translate the flow-of-funds concept to a sector basis comparable to USDA farm income and balance sheet accounting coverage. Our alternative account is highly consolidated, both because it is a first attempt and because of our desire to use *BSFS* and *FIS* published data. Still, we believe the statement in these more familiar terms gives a basis for understanding the disinvestment conclusion implicit in the FRB farm business sector SAUF statement.

But this demonstration merely scratches the surface of potential applications and extensions. Let us briefly suggest three. The simplest would be more grossing of entries within limits of presently collected financial data on agriculture. To illustrate, one could show the amount of new mortgage money committed as a source of funds and the amount of principal payments as a use of funds, instead of just the $2.2 billion net increase. This more detailed information adds interpretive content and can be provided, given any predetermined set of account transactions. Second, one could disaggregate the alternative account by expanding the number of transaction categories. Mortgage and contract paper on land held by nonactive farmers who sell out would likely be interpreted as a different kind of investment from that held by financial intermediaries. The decision on what kinds of transactions should be considered structurally unique requires us to refine our theories. Third, a more general and more data-demanding form of disaggregation would be to expand the number of transactors or sectors. This could be carried on in at least two fruitful ways. One would be to disaggregate the present farm sector defined in our alternative account into several sectors. Depending upon what was judged most important, operators could be separated from landlords, one economic class of farm from others, those producing one type of product from others, those in one geographical location from others, those with one legal form of organization from others, and so forth. Again, it is largely a matter of theorizing which groups may have unique financial flow characteristics that are meaningful in explaining economic behavior. The other method of disaggregation among transactors would be to add sectors for farm-related businesses as a device for measuring the extent and kinds of financial interdependence being created by vertical integration, etc. Perhaps the rest of the economy could be entered as a separate sector for analysis. Costs and sources of data place severe limits on how far such reporting can be carried.

If the accounts are to be put to analytic uses in order to derive economic parameter estimates, and not just as a descriptive mechanism, further analysis is needed. One possibility is the simulation of a system of estimators for the components of the farm sector SAUF statement. This could be used as a framework to measure and test relationships of the various components.[7]

Summary

Flow-of-funds analysis as a social accounting tool is a necessity when measuring the changing financial structure of the farm sector. Much of its value lies in disaggregating flows of funds

[7] By adopting certain conventions for exogenous variables, one could solve the proposed system of equations, say on a recursive basis, over time. Our preliminary efforts in this area indicate that a simultaneous solution of the equations would be required.

from various institutional and noninstitutional sources of funds to various classes of users, i.e., economic classes of farms, operators, landlords, etc. This would aid in analyzing both the efficiency of the sources of funds in meeting demand and the relative benefits to groups of users who are supplied. This framework could provide the basis for new policy determination and for welfare comparisons under present programs not otherwise possible.

The purpose of FOF analysis in a national economic accounting system is to relate changes in balance sheets with income accounts. For our purposes, the role of FOF analysis is to relate changes in current accounts as given in the *Farm Income Situation* to changes in the *Balance Sheet of the Farming Sector*; to describe *how* we moved from one year's balance sheet to the next. Thus, it is important that the sector SAUF statement be definitionally and conceptually consistent with the *FIS* and *BSFS*. The scope and orientation of the FRB farm business sector SAUF statement is designed as part of their national FOF matrix. Thus, its basis is not internally homogeneous with the other farm sector social accounts.

Agriculture is blessed in certain respects with a multitude of statistical data sources. In terms of social accounting, continual examination of these sources as they relate to what it is we really are to measure is required. A coordinated effort to make the various accounts as consistent as possible is necessary if we are to prevent either their misuse or their nonuse.

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Needed Redirections in Economic Analysis for Agricultural Development Policy*

Peter Dorner

Economic literature identifies development with average rates of increase in real output per capita. Little research has focused on interrelations between productivity increases and other indicators of development such as the reduction of mass poverty, unemployment, and inequality. Such omissions may be a function of the way agricultural economics developed in the United States. Here a positive correlation between increased production, employment, and income-earning opportunities was assumed inherent in the family farm system and the relative labor-scarce conditions. Problems emerging in recent years throw considerable doubt on the appropriateness of these assumptions.

I

Within the past several decades, especially the one just ended, agricultural economists have become increasingly concerned with agricultural *development* policies. I underline development since this is a new emphasis.[1] Agricultural economics and the related rural social sciences emerged as academic disciplines at about the turn of this century, after U.S. agriculture was far along the road to modernization. Initially, agricultural economists were concerned with problems of farm management and tenancy. Later, problems of marketing, credit, price and income protection, resource conservation, and aggregative characteristics of demand and supply became subfields of specialized interest and research. Since the discipline "grew up" after the basic economic, social, and political institutions of production and distribution were established, policy issues of concern to researchers were essentially those dealing with imperfections of the system—obstacles and barriers (to the free flow of information and resources) inhibiting the most efficient use and combination of *given* resources [24, pp. 725–729; 35, p. 83].

A look at the "growth of government in agriculture" [41, 1, 39] reveals a fairly close correspondence between policy issues in U.S. agriculture and the development of specialized areas of research.[2] The shape of agricultural economics as a discipline reflects the range of issues that arise in agricultural policy. Organized systems of thought are the result of man's efforts to cope with experienced difficulties. The configuration of such a system of thought will be different if establishment of basic institutions is a key issue, in contrast to the system of thought that emerges from inquiry into policy issues that arise *within* an established and accepted institutional framework [14, p. 4].

At the time of United States' independence, economics was just emerging as a recognizable, separate branch of moral philosophy. A major policy issue in the late 18th and early 19th century was the nature of economic organization to establish in agriculture. The resulting system of family farms was rationalized more in terms of political theory (a major reaction to European feudalism) than economic theory [16].

The system of economic, social, and political organization was firmly established by the time problems of agricultural policy attracted the attention of professional economists. Had our earlier policies fostered a feudal hierarchy or communal ownership of land instead of fee simple ownership and family farms; had our social organization developed around the extended family or the tribe instead of the nuclear family living in relative isolation on its farmstead; had our political system been one of centralized control and management of the economy with all transactions involving land, labor, capital, and commodities regulated by

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[1] Development is here viewed in the broad sense of expanding opportunities and the human capacities needed to exploit them, along with a general reduction of mass poverty, unemployment, and inequality [36, 31].

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[2] Note also current policy issues (poverty, resource and environmental management, population, urban congestion, agricultural development, etc.) and the corresponding growing interest and research specialization (including new institutes and professional journals) in all of these areas.

central political authority instead of the local automony and free private enterprise of individuals in their economic activities; much of our theory of the firm, of markets, of pricing, and of equilibrium would be irrelevant. In fact, we most likely would not have them. *They could be developed and perfected only within a particular political and institutional context.* They provide no analytical insight into a system whose institutions are different.[3]

Thus, there is little reason to believe that the concepts and hypotheses derived from our theories are entirely relevant to all of our country's currently recognized problems; they are even less to relevant to problems facing the poor, agricultural countries. The need, it would seem, is to understand institutional systems and the nature of public policy issues.

On some problems our theories and professional economic analyses are serving reasonably well in the United States and in other industrialized countries. The relevant questions are being asked and the data needed for analyses are being generated. But the categories in our census and other statistical series are not accidental.[4] They too are products of the policy issues and the theoretical formulations developed through the interaction of problems and ideas.

On other important policy questions, however, present theories provide little insight even on U.S. issues: environmental quality, poverty, race relations, a more acceptable distribution of economic and political power, congested cities, rural development, automation, and basic changes in the structure of resource ownership. Present theories do not seem to encompass these issues; they do not help us to formulate the right questions; hence, appropriate data are not available, and fundamental policy questions tend to fall outside the boundaries of traditional academic disciplines.[5]

II

A basic question is whether economics, or any other social science, has anything significant to say on matters of development policy. More fundamentally, are the social sciences capable of generating guidelines for public policy that are in some sense "better" than those formulated by other means and criteria? Or are the value questions of public policy subject only to political compromise or the dictates of dogma, coercion, and personal tastes?

This depends, it seems, on one's view of the role of theory, how it is developed, and the manner in which it is tested. If one assumes that economic theory develops in some pure form independent of policy issues existing within a specific institutional matrix, it follows that theory can have an "independent career" and be set apart in a separate domain.[6] This view may not be too harmful with respect to those aspects referred to by Kuhn as "normal science" or the "mop-up work" growing out of established theory.[7]

[3] N. Georgescu-Roegen has observed, "As soon as we realize that for economic theory an economic system is characterized exclusively by institutional traits, it becomes obvious that neither Marxist nor Standard theory is valid as a whole for the analysis of a non-capitalist economy, i.e., of the economy of a society in which part or all of the capitalist institutions are absent. A proposition of either theory may eventually be valid for a non-capitalist economy, but its validity must be established *de novo* in each case . . . . Even the analytical concepts developed by these theories cannot be used indiscriminately in the description of other economies. Among the few that are of general applicability there is the concept of a production function together with all its derived notions. But this is due to the purely physical nature of the concept. Most economic concepts, on the contrary, are hard to transplant . . . " [13, pp. 147–148].

[4] Seers has noted that " . . . lack of data on poverty, unemployment and inequality reflects the priorities of statistical offices rather than the difficulties of data collection. The conceptual problems of these measures do not seem to be more formidable than those of the national income. We have just grown accustomed to ignoring [them]" [36, p. 3].

[5] "Nowhere," says John Gardner, "can the operation of vested interests be more clearly seen than in the functioning of university departments . . . [the department] assesses the significance of intellectual questions by the extent to which they can be answered without going outside the the sacred territory" [12, p. 98].

[6] "To accept the distinction between 'pure' and 'applied' economics as generally valid and fundamental is not only to accept the view that 'theory' in its pure form can have an independent career but that it can be validated in some way other than by 'application' . . . The crux of the issue is simply this: that the only alternative which we have to the validation of inquiry by problem solving is a reliance either upon self evidence of fact or principle as the foundations of knowledge—or upon revelation. Both of the latter alternatives are incompatible with a genuinely scientific viewpoint" [30, pp. 664 and 674]. (See also [6].)

[7] "Mopping-up operations are what engage most scientists throughout their careers. They constitute what I am here calling normal science. Closely examined, whether historically or in the contemporary laboratory, that enterprise seems to attempt to force nature into the preformed and relatively inflexible box that the paradigm supplies. No part of the aim of normal science is to call forth new sets of phenomena; indeed those that will not fit the box are often not seen at all. Nor do scientists normally aim to invent new theories, and they are often intolerant of those invented by others.* Instead, normal scientific research is directed to the articulation of those phenomena and theories that the paradigm already supplies" [22, p. 24].

* Here Kuhn cites Bernard Barber, "Resistance by Scientists to Scientific Discovery," *Science* 134:596–602, 1961.

Another position, taken in this paper, is that as major changes occur in society the existing body of theory (developed through the study and eventual resolution of major policy issues) becomes inadequate and fails to comprehend the new policy issues that confront society. The major breakthroughs and theoretical syntheses in economics have come about from attempts to deal with major policy crises. Smith, Ricardo, Marx, and Keynes were all deeply immersed in the policy issues of their time, and their theoretical advances resulted from their inquiry into the possible resolution of questions central to economic policy.[8] Advances in theory have always been constructed on the basis of detailed and specific research into the very issues that could not be forced "into the preformed and relatively inflexible" boxes available from existing theory [22, p. 24].

Emphasizing the need for research on policy issues does not mean that the goals of policy are set by politicians, bureaucrats, or pressure groups and that the role of research is merely to seek the most efficient means of arriving at such predetermined goals. Rather, it means that the investigator must be concerned with both ends and means. "Since development is far from being achieved at present, the need is not, as is generally assumed, to accelerate economic growth—which could even be dangerous—but to change the nature of the development process" [36, p. 3].

This view holds certain dangers. For example, it raises the question of objectivity in research.[9] This is perhaps why many social scientists deny that they are working on policy questions and maintain that—as scientists—their only concern is establishing value-neutral relationships. This latter function is of great social significance, and most social scientists will be engaged only in such studies. Indeed, new theoretical breakthroughs are impossible without them [22]. But without direct attention to relationships not prescribed by present theories, some of the most pressing public policy questions are ignored.

It may be helpful at this point to note a fundamental difference between the physical and the social sciences. Both physical and social scientists can carry on much of their normal science under laboratory conditions, but social scientists will always conduct some of their research within the context of human society. When a crisis in policy emerges, when accepted theories fail to offer insights into phenomena readily observed, when these anomalies become so obvious that they can no longer be ignored, a new theory cannot be validated except as it is tested in practice. In physical science this can still frequently be done under laboratory conditions; but in economics it requires new directions in policy. Its measured consequences must then serve as the experimental test. The Keynesian reformulation of the 1930's is perhaps the best and most recent example in the field of economics. Today, many economists are indeed engaged in the normal science that is not directly concerned with ends or values. But this is made possible by the new Keynesian paradigm which has once again (for the industrialized, capitalist countries) relegated many evaluative or "normative" issues to the level of assumption, removing them for the time being from the immediate field of inquiry. This makes possible the common practice of reading prescriptions for public policy directly from the refined Keynesian models (a practice which Keynes himself did not recommend).[10] But such prescriptions could not command the respect they do if the new theoretical constructions had not been tested—in the only meaningful terms possible—through their practical influence in shaping public policy and resulting in measured and anticipated consequences.

In the United States we have begun to accept as a measure of progress the number of people lifted from the misfortune of being poor. There is a growing recognition that development prob-

[8] "One of the results of any survey of the development of economic doctrines is to show that in large measure the important departures of economic theory have been intellectual responses to changing current problems" [25, p. 13].

[9] The problem-solving approach to inquiry " . . . easily and naturally frays out into a mere servicing of practical judgments. In fact, it requires strenuous intellectual effort to avoid this very outcome. Under such circumstances we gradually drift into an acceptance of the 'problems' as formulated by our constituency. The next step is simply that of making 'investigators' the mere tools of various interests . . . Yet the issue must be faced. The argument seems inexorable, that there is no other alternative in genuinely scientific inquiry to having both the roots of inquiry and the final tests of validity in practical problem solving" [30, pp. 675–676].

[10] "The object of our analysis is, not to provide a machine, or method of blind manipulation, which will furnish an infallible answer, but to provide ourselves with an organised and orderly method of thinking out particular problems; and, after we have reached a provisional conclusion by isolating the complicating factors one by one, we then have to go back on ourselves and allow, as well as we can, for the probable interactions of the factors amongst themselves. This is the nature of economic thinking" [21, p. 297].

lems are not confined to some far-off "less-developed country," and people are beginning to realize that development is more than capital, investment, and markets. It is a complicated process of institutional change, redistribution of political power, human development, and concerted, deliberate public policy efforts for redistributing the gains and losses inherent in economic growth [7, p. 291].

Despite such recognition, these issues are still often treated as "fringe problems," outside the mainstream of economic policy. And development economics, so far as I can determine, does not incorporate these issues into its analysis. As a result, the relevancy of development economics to development is being questioned [36, 4]. In viewing the core economic theory requirements at major Ph.D.-granting universities and the content of preliminary examinations, one would hardly suspect that such problems exist or that theory has any bearing on research related thereto.[11] While development questions in the United States are becoming more critical, they are at the heart of public policy issues in nonindustrialized countries. Yet U.S. universities are presuming to educate and confer Ph.D. degrees on candidates from these countries.[12]

There is, it would appear, a crisis situation developing in economics (and perhaps in the social sciences generally) in the sense defined by Kuhn—"Crisis and the Emergence of Scientific Theories" [22, pp. 66–76]. Unless some key development issues, presently ignored, are directly addressed in research, this crisis may challenge the very legitimacy of economics. As Boulding reminds us,

> The teaching of every profession produces a certain amount of what Veblen called "trained incapacity" and we should certainly look with a critical eye at economics to see if we are not doing this. If the training of the economist leads to his neglecting certain important aspects of the world about him, once he is in a position to give advice and to have his advice taken, disasters might easily ensue. . . When one is giving advice, therefore, about a system that involves the total society, it is extremely dangerous to be overtrained in a certain abstract element of the total process. If we run into enough of this we may find indeed a widespread reaction against economics and a withdrawal of legitimacy from it. It is my own view frankly, at this point, that we must move toward a more integrated and perhaps even a rearranged social science, that the existing departmental and disciplinary lines often mask real problems. . . [2, pp. 306–307].

III

Given the rapid population growth in most of the developing countries, the large proportion in agriculture, and the continuing growth of absolute numbers dependent upon agriculture [9], it is surprising to see how little analytical attention has been given to the need for creating employment and improved income-earning opportunities in rural areas. There is a vague hope that programs designed to increase production will result in agricultural development irrespective of the short-run employment and distributional consequences of such programs. However, experience over the past decade indicates that the questions of increased agricultural production and a more equitable distribution of the fruits of that production must be viewed as parts of the same process. Policies designed to cope with one of these to the exclusion of the other have not succeeded.

These two aspects of development (increased production and a more equitable distribution) are sometimes viewed as being totally independent [3]. The first is seen as the key to development while the second is considered a peripheral problem of welfare or social justice. Some even assume that economists have the analytical tools that permit them to make policy recommendations for increased efficiency in production, but that the problem of a more equitable distribution is a political or cultural matter [17].

In most of the nonindustrialized countries a majority of the people depend on the land for employment; jobs in manufacturing are growing much less rapidly than manufacturing output; and the number of people dependent on farming for a livelihood is increasing. To achieve the benefits that may accrue from what Owen has called "farm-financed social welfare" requires that opportunities—even subsistence opportunities—be provided [27, p. 61; 28].

Policies that emphasize modernization and

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[11] "Workshop on Core Economics" sponsored by the Agricultural Development Council, October 10–11, 1967, held at ADC offices in New York.

[12] "If a student's formal course training is limited to two years of graduate study and he expects to work on development problems, he is, I'm afraid, in danger of finding that he has acquired a lot of mental luggage of dubious utility while he has not been expected to think very deeply on questions basic to an effective attack on the problems of development. It is not really an answer to say that you are giving him his analytical tools and that his thinking can come later. If he has not been made aware of the basic issues in his university training, he may well pass through life unaware of their very existence" [4, p. 20].

increased production from the commercial farm sector without explicit attention to the creation of employment opportunities will yield increased output of certain farm commodities and growing labor productivity for a part of the farm labor force. But they tend to widen the income disparities and throw the burden of adjustment on the disadvantaged who join the ranks of the landless, become migrant seasonal workers, continue to crowd into existing small farm areas, move out to rapidly shrinking frontiers, or join the underemployed in the cities. There is no evidence that the increased volume of commodities moving through commercial channels as a result of increased production creates sufficient jobs for workers displaced by modernization or for the continuing new additions to the rural labor force.

Poverty (the massive poverty among the majority of people in the less-developed countries) is not only or primarily a welfare and humanitarian problem. It is a problem that has direct and important implications for increased productivity. Supply *does not* create its own demand under conditions of a highly skewed income distribution. To focus primarily on production widens the income gap between rich and poor. It is impossible in many circumstances of development to separate the issues of production and distribution, since distributional measures may be the key to achieving increases in production. And the trickle-down theory of distribution has never worked, especially under conditions of concentrated economic and political power.[13]

Why are policies not formulated to accommodate both of these requirements—increased production and increased employment with a more equitable distribution? The distributional questions, of course, raise many tough issues. Accordingly, and regretfully, policy recommendations of professional analysts using highly sophisticated models usually ignore employment and distributional aspects. Recommendations are too often based on private or project decision-making criteria rather than those appropriate to the interests of the entire nation. Some redirections in economic analysis are required. Three concepts in such a redirection (and examples of assumptions that frequently preclude their explicit inclusion in analyses) are highlighted in the following sections.

1. *Creation of secure opportunities on the land.* The "war on hunger" position tends to assume that if there are hungry people, food should be produced by the cheapest, most efficient means possible. Yet frequently, and especially when viewed from the private interest of an individual firm, this course of action includes displacing people with machines. And professional analysts, viewing the problem with decision-making criteria appropriate to the private firm while ignoring the possible lack of correspondence between private and social costs and benefits, can reach conclusions such as the following: "One reason for the high cost [of corn in Guatemala] is the amount of hand labor required. Hence, my desire to try out the corn picker" [29, p. 716]. However, this may not be a solution at all once the need for employment creation is taken into account. Even if means could be found to tax away or otherwise confiscate the increased production ". . . a nation cannot put most of itself on the dole, even if money and food are available for distribution" [26, p. 224].

Land must be viewed as a vehicle for human development as well as a resource for food production. As Raup has put it, "Wherever there is surplus agricultural labor and shortage of working capital, the task of the tenure system is to put people to work" [33, p. 274].

It has become an article of faith, at least among many professionals from the industrialized countries, that mechanization (mechanical technology and automation generally) always creates as many jobs as it destroys, sometimes more. According to this faith, there may indeed be some short-run problems of labor displacement and some structural unemployment. But given time, the new technology creates demand for labor in many areas of the economy through its various linkages, and eventually employment will rise to a higher level.

This assumption may be justified in a highly industrialized nation. But does the same assumption apply to a country that does not produce its own technology? In the United States, for example, the mechanical cotton picker displaced workers by the tens of thousands [5]. Many of the workers displaced (though certainly not all) and especially the sons of these workers did find employment among the vast

[13] *The Economist* makes the following comments on FAO's "Indicative World Plan": "As long as incomes are so unevenly distributed within the developing countries themselves, and so little inroad is made with their traumatic unemployment problems, the people who are starving will not have the money to buy the food, even if it is there. This is where the planners of Asia, Africa and South America would like FAO guidance, but so far they only get alarming figures and some general advice" [15, p. 75].

complex of industries interrelated with the production, sale, and servicing of cotton pickers—steel, rubber, oil, machinery manufacture, transport, farm implement sales and service, etc. But what about Nicaragua, which imports cotton pickers from the United States? Most of the vast complex of industries linked with the cotton picker does not exist in Nicaragua; it remains in the manufacturing country.[14]

The entrepreneur of a large farm enterprise may find the importation of labor-displacing machines highly profitable due to a variety of circumstances, many of them related to government policies: overvalued exchange rates, subsidized credit, rising minimum wages and fringe benefits, etc. Reasoning from analogy, U.S. and European experience of farm enlargement and mechanization is sometimes cited to support this type of development. But such an analogy is inappropriate for the widely different situation with respect to factor proportions and *real* factor costs in nonindustrial societies (in contrast to existing factor prices which are often controlled and distorted by some of the above policies) [11].

The cotton picker case illustrates the general principle involved; it does not argue against all modern, imported technology. Much depends on what the machines will be used for. In an agriculture with an overabundant and growing labor supply; it is unlikely that one can make a logical case for importation of labor-saving machinery if the problem is viewed from the standpoint of national policy rather than profit maximization of the firm [19]. If the agricultural sector is to make its most effective contribution to economic development, it must not only improve labor productivity for a select group but must also expand employment opportunities [20, 40].

Mechanical power and equipment might sometimes be justified in terms of increased yields due to better tillage or timeliness of operations. But there is sufficient experience of countries where such needed machine services were provided to an agriculture otherwise based on labor-intensive production practices.

On the basis of his model of rural outmigration and urban unemployment, Todaro concludes:

> Perhaps the most significant policy implication emerging from the model is the great difficulty of substantially reducing the size of the urban traditional sector without a concentrated effort at making rural life more attractive [40, p. 147].

But how is rural life to be made more attractive? Presumably public investments in rural education and health services would help; and funds used to accommodate rural migrants in the cities might be diverted to rural areas. Yet such services cannot be extended rapidly because of both capital and professional manpower shortages. Higher minimum wages for farm workers could be counterproductive so long as investment decisions in the farm sector are made by private entrepreneurs. A higher minimum wage might lead to a shift to labor-extensive enterprises or to an acceleration of machine substitution for labor. Even with low wages there is a strong incentive on large farms to mechanize and simplify labor supervision. It is almost impossible to find farms of, say, 1,000 hectares in rice or cotton that are planted, tended, and harvested mainly by hand labor. These farms either mechanize or operate with a sharecropper system. To get at the crux of the matter, "making rural life more attractive" in most cases means providing the farm family with ***a secure opportunity on the land.*** Land tenure arrangements and size of holdings must be included as variables in the analysis. But the basic assumptions underlying production and distribution theories take these as "givens."[15]

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[14] The problem is compounded if, as Singer has pointed out, the investments and the production processes are actually controlled by foreigners. "The main secondary multiplier effects, which the textbooks tell us to expect from investment, took place not where the investment was physically or geographically located but (to the extent that the results of these investments returned directly home) they took place where the investments came from. I would suggest that if the proper economic test of investment is the multiplier effect in the form of cumulative additions to income, employment, capital, technical knowledge, and growth of external economies, then a good deal of the investment in underdeveloped countries which we used to consider as 'foreign' should in fact be considered as domestic investment on the part of the industrialized countries" [37, p. 475].

[15] "Distribution theory today concerns itself, in essence, with tracing out the effects of various policies in distributing economic fruits among persons who own or otherwise command control over resources . . . In current theory, distribution of ownership or other control of resources among people is 'given' . . . In terms of the dynamics of economic development, however; the real problem of distribution is: 'How does ownership or other control over resources come to be distributed in the manner it is?' . . . The question is not, for example, whether a landlord and a tenant each receives the appropriate return for the resources he controls; but rather, is it appropriate, from the standpoint of the economic development of the country in question, for the landlord and the tenant to have these particular proportions of the nation's resources under his control" [24, pp. 729–730].

2. *Development of human abilities and capacities.* Another reason why the employment issue gets little attention is that in the less-developed countries, the most abundant potential resource usually is labor. I say *potential* because training and work experience are needed to transform raw labor power into the manpower resource (with skills, experience, and discipline) required for development. An abundance of people does not necessarily rule out labor shortages in selected occupations. The scarcest resource generally is capital. Given the abundance of people, there has been a tendency to ignore the need for investment in and development of the labor potential. Instead of viewing land as a vehicle for employing people and for developing the skills and experience required of the rural labor force, land has been viewed primarily as a resource to be efficiently combined with scarce capital so as to maximize agricultural output.

T. W. Schultz has written a good deal on the issue of investment in human capital [34], but he places primary emphasis on formal schooling. I do not deny this need, but formal schooling is not the only and not always the most significant dimension of education. Furthermore, many poor countries have not yet been able to supply even elementary schooling for large numbers of their people. Under these circumstances, economic activity should be designed to produce educational effects. Productive work can offer experience and discipline as valid as that gained in the classroom. It is different, to be sure, and neither kind of education is alone sufficient. Work experience can be directed and enriched by learning obtainable only from school situations; schoolroom education can be enhanced by work experience.

The manner in which increased production is achieved, and the number of people who participate and reap some benefits from the experience, may be as important as the production increase itself. One gets a different perspective regarding the role of land if (in addition to its accepted function in the production of farm products) it is viewed as a vehicle both for creating economic opportunities and upgrading the human skills and capacities required for their exploitation [8, p. 12].

Man is a resource to be used (along with land and capital) as well as the user of resources. An individual plays a dual role—he is both the user and the used, the interested and the object of interest, the exploiter and the exploited.

In a society where economic and political power are widely shared, there is a continuous attempt to modify institutional structures and norms in order to keep this process of "using others" mutually beneficial. Procedures are designed so that individuals and groups, in pursuing their private interests, are not injuring (preferably, are furthering) the interests of other individuals and groups. When mutuality in the process breaks down and conflicts intensify, zones of discretionary behavior of the individuals and groups involved must be redefined in order to reestablish mutuality in the processes of associated living.

The common formulation in resource allocation-efficiency models is to view man as labor power—as the object of use. This view, far from being value-neutral, accepts the status quo power positions and ownership patterns of land and capital. In fact it places the weight of authority of "scientific analysis" in the camp of present owners. Under conditions of vast and increasing inequality, policy prescriptions based on such efficiency models are consistent with the poor man's view of the world: "Them that has—gets".

3. *Inclusion of income distribution as a variable in analyses.* Economic literature tends to deemphasize the income distribution consequences of the development process. Since land tenure arrangements are most directly associated with the creation of and access to income-earning opportunities and their distribution, these arrangements receive only passing mention in the economic literature on agricultural development policies.

If the task of development is conceptualized to include income distribution as an endogenous variable, some of the economists' most powerful ideas and tools lose some of their analytical leverage. For example, marginal analysis and the accompanying planning, programming, and budgeting tools implicitly assume certain nonchanging structural parameters. Yet once an elaborate and somewhat arbitrary measurement emerges, as from benefit-cost analysis, a strong faith is placed in it. The unstated assumptions remain unstated and are frequently ignored. The higher the benefit-cost ratio, the "better" the project.

However, the results of these calculations are directly conditioned by the pattern of income distribution.[16] Investments in the increased

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[16] "... Cost-benefit analysis as generally understood is only a technique for taking decisions within a framework which has to be decided upon in advance and which in-

production of chickens and beans rather than airlines and television sets might give a good benefit-cost ratio if the pattern of income distribution were changed. Poor people, lacking the money votes, cannot register their needs or desires through the market mechanism. But change the income distribution and you change the structure of demand, thus changing the benefit-cost ratios of various projects and in turn altering investment priorities.[17]

Assumptions like those described in these examples allow certain strategic developmental questions to fall between the analytical slats: productive employment for the growing rural labor force; creation of opportunities for the development of human abilities and capacities; and ownership distribution of land and other resources. An agricultural economist, using a farm management approach, may ignore the displacement of workers or their need to find viable opportunities on the land. He is concerned with profit maximization from the resources available to the firm. Even an agricultural economist dealing with farm policy for the agricultural sector could ignore these questions on the assumption (well founded or not) that industrial and other nonagricultural activities are available for the absorption of excess rural labor. Nor does a macroeconomic approach assure that these strategic questions will be addressed in the analysis. While Keynes may have shown a deliberate disregard for the supply side of investments (and focused only on their demand-creating consequences) [23], post-Keynesian development economists seem to have overemphasized the supply consequences.

There is indeed an implicit assumption that somewhere policies are being implemented to maintain full employment and that when a laborer moves from one job to another it always results in increased productivity. But these are unwarranted assumptions in most cases of less-developed countries. Indeed, these assumptions point to some of the critical problems of development.[18]

IV

What conclusions are to be drawn from the arguments set forth in this paper? First, we need additional criteria by which to assess development. This means inclusion of presently less measurable and quantifiable variables than the commonly accepted ones in use today. Second, both ends and means must be incorporated as variables in the analysis rather than accepting certain ends implicit in standard economic theories. Finally, distributional questions must be given higher priority on the research agenda.

Present theories may have much more relevance once we understand better the institutional context of specific country development problems and the "special case" out of which our own theories were constructed. If new theoretical extensions can accommodate the enlarged context, present theories may become more useful in guiding research in the very situations in which they are at present unsuccessful.[19]

New developments in theory are not simply willed into existence. The hypothesis suggested in this paper is that only as research concentrates on presently neglected policy issues within specific institutional contexts of individual countries can more adequate theories of agricultural development be constructed. It is

volves a wide range of considerations, many of them of a political or social character" [32, p. 685].

[17] Hirschman speaks of the centrality of side-effects in judging investment projects. "The quest for a unique ranking device probably accounts for the hostility of economists toward side-effect and secondary benefits. Yet this quest is clearly futile. How could it be expected that it is possible to rank development projects along a single scale by amalgamating all their varied dimensions into a single index when far simpler, everyday choices require the use of individual or collective judgment in the weighing of alternative objectives and in the trade-off between them? There is much to be said, it is true, for facilitating decision making by reducing the many aspects of a project to a few crucial characteristics, one of which would of course be the rate of return. It is one thing to permit, in this way, the decision maker to use informed judgment in making critical choices and trade-offs; it is quite another, however, for the technician to aim at dispensing with such judgment altogether" [18, pp. 162 and 179].

[18] ". . . [the] process of labor transfer is typically viewed analytically as a one-stage phenomenon, that is, a worker migrates from a low productivity rural job directly to a higher productivity urban industrial job. The question is rarely asked whether or not the typical unskilled rural migrant can indeed find higher-paying regular urban employment. The empirical fact of widespread and chronic urban unemployment and underemployment attests to the implausibility of such a simple view of the migration process" [40, p. 139].

[19] The theorist can be of help to the politician, the practitioner, ". . . if he refrains from trying to adapt uncritically models and measures designed in and for industrial countries, where priorities are different, but helps instead to develop policies, national and international, to mitigate the great social problems of the Third World . . . above all, the aim must be to change international attitudes so that it becomes impossible for the political leaders and social scientists of Europe and North America to continue overlooking, and aggravating, often inadvertently, the obscene inequalities that disfigure the world" [36, p. 6].

obviously asking a great deal of a man to be guided by present theories and preconceptions and yet to be continuously suspicious and to question them at every stage in his research. Nevertheless, this would seem to be the nature of the present challenge.

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Optimal Sizes of Farms Under Varying Tenure Forms, Including Renting, Ownership, State, and Collective Structures*

EARL O. HEADY

Variants in tenure forms cause a range of optimal farm sizes in countries of various stages of economic development. Aside from capital restraints, however, modifications can be made in cost functions associated with each tenure form. The optimal use of inputs and farm size then is theoretically the same for individually operated farms. In the case of private, state, and cooperative farms, however, the same resolution is not possible in the short run. If the objective of the cooperative farm is maximum profit per member, this tenure form always has an optimal size smaller than a private or state farm.

FARMS over the world are operated under a wide variety of size and tenure conditions. The dominant tenure pattern in Eastern Europe is one of state farms and cooperatives (collectives) operated as very large units. Side by side with these units are individual plots (individual farms in Poland and Yugoslavia, with the acreage dominated by private farms over socialized units). Farms are smaller in North America and are operated under a combination of tenure conditions, including share renting, cash renting, and owner operation. Still, farms in North America generally are larger than in Western Europe, with a similar mixture of tenure conditions. Some large plantation units prevail in less developed countries of Africa, South America, and Asia, but very small units operated under either ownership or rental dominate.

The variants in tenure forms, stage of development, political objectives, and resource markets are expected to cause a range of farm sizes to be optimal in the several world regions. However, we may ask how the optimal size of farms should vary under these diverse conditions. Or we may ask whether the variation in farm sizes is consistent with this range of developmental and tenure conditions and the implied objective functions of societies. As an initial appraisal, it would appear that while farms are larger and more diversified in Eastern Europe, they should be smaller and less specialized than in Western Europe and North America.

We propose that farms in Western Europe and North America may be too small or that those of Eastern Europe may be too large. This proposition is made in terms of the potential nature of production functions, stages of economic development, and relative factor prices (or relative factor scarcities in countries where prices are not freely established in markets). It abstracts from the political, social, and institutional environment which may dominate and place (sometimes only subjectively but in other cases as a legislated extreme) upper restraints in land area per farm in some countries (usually individual or private units) and lower restraints (usually state and cooperative or collective units) in other countries. Aside from these nonmarket restraints, the technological and factor scarcity conditions in Eastern Europe should cause farms to be smaller, or optimally no larger, than those in North America. Of course, technology and factor prices would not dominate farm size if constant returns to scale prevailed. Farms of both large and small sizes could exist side by side on an equal economic basis. Or the pattern of one country could be large units while that of another country could be small units and both would be operated with equal efficiency. Under the potential of high mechanization, however, cost functions can decline over an extended volume of the farm firm's volume or land area. Hence, larger optimal farms may be posed in countries such as Western Europe and North America where development is at higher stages, capital has a lower real price relative to labor, and capital technologies are more consistent with factor markets.

Tenure and Size

We shall return to these conditions of development and resource supplies or markets which relate to farm size. However, tenure conditions also pose differences in optimal farm size. If cooperative (collective) farms were organized for maximum benefit of their members as typically implied (supposing consumer or societal welfare is maximized through use of

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factor prices or weights to attain efficient factor combinations and efficiency), their short-run size could well differ from that of private (individual) and state (public) farms. The conditions of tenure even under private land ownership and individual operation also should cause similar variations in optimal size. Hence, we turn first to an analysis of optimal farm size under conditions of share renting, cash renting, owner operation, cooperative farms, and state (public) units. The analysis in this study is only of optimality relative to an objective function for the individual farm. Resolution of the questions and problems posed can be attained finally only as empirical cost function research is completed over a range of countries to establish the nature of cost and scale economies under various conditions of factor markets and economic development. Also, in contrast to this analysis using the firm's objective function as the criterion, a parallel analysis is needed relating society optimality to factor markets, social institutions, the conditions of competition that prevail in agriculture, and other sectors of national economies and political objectives.

This analysis is in a theoretical context. Previously we developed certain theoretical concepts relating to the effect of tenure on farming efficiency, equitable divisions of income, and commodity supplies [4, pp. 587–588; 5, ch. 20 and 21; 6; 7, pp. 52–64]. Others have added to this theory over time [1, 2, 3, 9]. Helmberger and Hoos [8] and Phillips [10] have examined certain organization theory of cooperative enterprises. The current analysis differs, however, in relating specifically to farm size and various types of production functions which might prevail.

Size Under Share and Owner Operation

The optimal normative size of an individual farm operated under ownership is defined by the magnitudes of various resource inputs for the various commodities. While several commodities may be produced, our illustrations refer to a single commodity or enterprise in order to economize in space. A multicommodity farm involves exactly the same theory, extended accordingly. For all situations analyzed in this paper we assume the production function:

$$Y = f(X_1, \cdots, X_j, \cdots, X_n) \tag{1}$$

where Y is product output, the X_j are resource inputs, P_y is price per unit of output, and P_j is the price per unit of the jth input ($j=1, 2, \cdots, n$). This function refers to a particular production period and the X_j are resources or their services consumed in this period. (Consideration of multiperiod resources, uncertainty and discounted or compounded prices would extend the presentation but would not change the general conclusions. Hence, we leave them aside for reasons of space.) Ex post and normatively, the optimal farm size is defined by the magnitude of Y and the X_j which maximize the profit or objective function. The objective or profit function, π, in this case is

$$\pi = P_y Y - \sum_{j=1}^{n} P_j X_j \tag{2}$$

and the first-order conditions defining optimization of the objective function are

$$\begin{aligned} \frac{\partial Y}{\partial X_1} &= P_y^{-1} P_1 \\ &\vdots \\ \frac{\partial Y}{\partial X_j} &= P_y^{-1} P_j \\ &\vdots \\ \frac{\partial Y}{\partial X_n} &= P_y^{-1} P_n \end{aligned} \tag{3}$$

where the marginal productivity of the jth resource is equated to its real price (i.e., the price of the resource divided by the price of the product).[1] It is elementary knowledge that this state of optimization prevails, assuming pure competition or prices that serve as constant parameters for the individual farm and no X_j is fixed in supply, only under conditions where the marginal productivities of each resource is declining and

$$\sum_{j=1}^{n} \frac{\partial Y}{\partial X_j} \frac{X_j}{Y} < 1.0$$

(decreasing returns to scale) prevail; that under these conditions, the marginal value productivity of each resource is equal to its price, the marginal rate of substitution of each pair of resources is equal to their respective price ratio,

[1] As noted later, if the total budget for investment in inputs is limited to K_0, the marginal productivity of the jth input will be at the higher level $(1+\lambda_0)P_jP_y^{-1}$ and the farm size will be restrained to the level $K_0 - \sum_{j=1}^{n} P_jX_j = 0$ (i.e., the latter equation will be added to the set of partial derivatives and we must solve for the $n+1$ unknowns λ_0 and $X_1, \cdots, X_j, \cdots, X_n$).

and the specified volume of output is produced with the minimum cost mix of inputs.

Solving the equation system in (3), we can determine the values $X_1, \cdots X_j, \cdots X_n$ that specify optimal farm size in terms of a single resource category or as the weighted aggregation of inputs. Substituting these values in the production function, we also can specify the optimal size in terms of output volume. With the criterion of optimizing the objective function, this size not only is optimal for an individual farm operated under private resource ownership but also would be the optimal size for a state-owned farm which is provided weights (e.g., prices) for inputs and outputs and is instructed to maximize the objective function accordingly. Hence, under given conditions of climate and soils (i.e., the production function) and relative weights for inputs and outputs, the optimal size of a privately owned individual farm is exactly the same as for a publicly owned state farm if we suppose that each has the same economically defined objective function to optimize. The optimal size, thus specified, is not expected to extend over the vast range represented by state farms in the U.S.S.R. and the private farms in North America. Under these economic conditions and criteria, political and noneconomic facets left aside, either the state farms of the former may be too large or the individual farms of the latter may be too small. We return to this comparison after we complete the comparative analysis of optimal size for individual farms.

Turning now to a farm operated under share prices for resources, we have the tenant objective function:

$$\pi = rP_yY - \sum_{j=1}^{n} P_jX_j \tag{4}$$

where the tenant receives r proportion of the output ($r<1.0$ and the landlord receives $1\text{-}r$ proportion) but bears all of the input costs.[2] Substituting the production function (1) for Y in the tenant profit function (4) and deriving the marginal condition for profit maximization by the tenant, the marginal productivity of the the jth tenant resource is the magnitude in (5):

$$\frac{\partial Y}{\partial X} = r^{-1}P_y^{-1}P_x \tag{5}$$

It will be r^{-1} times greater ($r^{-1}>1.0$) than the marginal productivity of the same resource for the owner-operator. This greater productivity corresponds with a smaller input and therefore a smaller farm, as measured by resource magnitudes and output volume.

Under certain apparent conditions, the divergence in optimal size of individual farms under owner and share-rented conditions can be resolved as follows: If the tenant supplies s proportion of the inputs while the landlord supplies $1-s$ proportion, the tenant's objective function becomes (6). The corresponding landlord objective function is (7).

$$\pi_t = rP_yY - s\sum_{j=1}^{n} P_jX_j \tag{6}$$

$$\pi_1 = (1-r)P_yY - (1-s)\sum_{j=1}^{n} P_jX_j \tag{7}$$

The corresponding marginal condition for the jth resource under tenant and landlord profit maximization is that respectively in (8) and (9).

$$\frac{\partial Y}{\partial X_j} = sr^{-1}P_y^{-1}P_j \tag{8}$$

$$\frac{\partial Y}{\partial X_j} = \frac{(1-s)}{(1-r)}P_y^{-1}P_j \tag{9}$$

If r is not equal to s (i.e., if landlord and tenant do not share the cost of inputs in the same proportion as they share outputs), the optimal farm size, from the standpoint of objective function optimization, will differ in both cases from the optimal owner size as implied by the marginal conditions of (3). If $r<s$. the optimal tenant size will be smaller than for the owner while the optimal landlord size will be larger since then $(1-r)>(1-s)$.[3] If, however, we

[2] Under this formulation, if we suppose the tenant supplies all n resources, the tenant farm would be akin to a franchise for farming in which the operator supplies all resources and pays a share of the product as a price of the franchise or right to farm. We can look upon this as a "pure type" tenant farm in order to simplify the analysis. In reality, of course, the landlord furnishes the land and other resources; but the general logic is the same and we retain the "pure case" example for reasons of simplification. We have already analyzed resource efficiency and use in the short-run context of an owner furnishing a given land input and tenant supply of other resource inputs [5].

[3] The marginal productivity in (8) for tenant optimization will be larger than for the owner in (3). This conforms with lower inputs for the tenant and a smaller size or volume. Conversely, the optimal magnitude of the marginal product for the landlord in (9) is smaller than for either the tenant (8) and the owner (3) with a correspondingly larger farm posed.

make $r = s$, so that both tenant and landlord pay the same share of input costs and receive an identical share of the output, then $s\,r^{-1} = 1.0$ and $(1-s)(1-r)^{-1} = 1.0$ and the optimal magnitudes of the marginal products for tenant (8) and landlord (9) will be the same as for the owner-operator (3). Hence, solving the sets of marginal productivity equations for magnitudes of inputs each for the tenant, landlord, and owner-operator, farms of identical size will be specified.

However, these identical optimal farm sizes hold true only under certain capital supplies. Capital limitations must be of the same relative magnitude for all. In case $r = s$, but the tenant has an upper limit of K_t capital and the landlord has an upper limit of K_1 capital to invest in resources, their respective profit functions will be modified as in (10) and (11) where λ_t and λ_1 are conforming La Grange multipliers.

$$(10)\qquad \begin{aligned}\pi_t &= rP_yY - s\sum_{j=1}^{n} P_jX_j \\ &\quad + \lambda_t\left(K_t - s\sum_{j=1}^{n} P_jX_j\right)\end{aligned}$$

$$(11)\qquad \begin{aligned}\pi_1 &= (1-r)P_yY - (1-s)\sum_{j=1}^{n} P_jX_j \\ &\quad + \lambda_1\left[K_1 - (1-s)\sum_{j=1}^{n} P_jX_j\right]\end{aligned}$$

Now the conforming marginal conditions for optimization of the tenant and landlord objective functions are respectively (12) and (13).

$$(12)\qquad \frac{\partial Y}{\partial X_j} = (1+\lambda_t)sr^{-1}P_y^{-1}P_j$$

$$(13)\qquad \frac{\partial Y}{\partial X_j} = (1+\lambda_1)(1-s)(1-r)^{-1}P_y^{-1}P_j$$

The marginal productivities in (12) and (13) will be equal, and conforming optimal farm sizes will exist for tenant and landlord only if $\lambda_t = \lambda_1$. This condition will prevail only if $s^{-1}K_t = (1-s)^{-1}K_1$ since the set of partial derivatives in (3), denoting first-order conditions of profit maximization, has an added equation:

$$K_0 - \sum_{j=1}^{n} P_jX_j = 0$$

for an owner,

$$K_t - s\sum_{j=1}^{n} P_jX_j = 0$$

for the tenant, and

$$K_1 - (1-s)\sum_{j=1}^{n} P_jX_j = 0$$

for the landlord. Hence, K_0, K_t, and K_1 must be proportional to the shares of input quantities for owner, tenant, and landlord respectively if optimal farm sizes are to be equal in a "mixed tenure" of individual farms.

Short-Run Cost Functions for Cash, Share, and Owner Operation

Long-run optimal farm size from the standpoint of operator optimization and relatively equal capital supplies (degree of uncertainty, institutional arrangements, etc., being the same) should be the same for cash-rented and owner-operated farms, except for unique long-run variations (i.e., all factors variable and combined in optimal proportions). Hence, we need not distinguish between long-run optimal sizes for owners and cash tenants. Similarly, under competition and long-run market equilibrium, the cost function and theoretical equilibrium size of firms should be the same under cash rental and owner operation. However, some interesting differences do arise in short-run cost functions and theoretical size of farms for minimum average costs.

Suppose the short run is characterized by a fixed land input but other factors are allowed to vary. The situation might have prevailed in a country (e.g., the United States) where the number of acres is institutionalized (as once at 160 acres, a configuration that still relates to modal farm sizes available in the market). Such a short-run "fixed size" prevails fairly rigidly in some countries in providing a given area per farm (e.g., Poland, Yugoslavia, and some other countries). The farm firm can vary its volume of output (i.e., its size as expressed in production or investment in input categories other than the fixed resource). While the exact nature of average cost functions will depend on the production function, prices of factors and relative importance of the fixed and variable terms of the total cost function, let us suppose the short-run total cost function, T_0, in (14) for an owner operated farm where Y is output.

$$(14)\qquad T_0 = 100 - 10Y + 5Y^2$$

(We have "forced" the conventional U-shaped average cost function by supposing diminishing marginal productivity for other resources as they are increased on the fixed input or area

of land). Now, a cash tenant has the total cost function, T_c, in (15) where we suppose the fixed rent paid the land owner not only covers the previous fixed costs (where the landlord's and renter's fixed costs sum to 100) but also includes a return to the land owner's resources equal to half the fixed costs in (14).

$$T_c = 150 - 10Y + 5Y^2 \tag{15}$$

Further, suppose a share tenant who pays half of the production as rent to the landlord bears all the costs but has fixed costs (attached only to capital and not to real estate) equal to half of those for the owner-operator in (14). The share tenant's total cost function then is (16) where the variable cost component of the equation is twice (since he shares half the yield) that for the cash renter and owner-operator.

$$T_s = 50 - 20Y + 10Y^2 \tag{16}$$

The corresponding average cost functions for owner, cash tenant, and share tenant are respectively those indicated as AC_0, AC_c, and AC_s in Figure 1. The short-run farm size (the volume of output) which gives minimum average costs for the share tenant will come at a smaller output (2.24) than for the owner (4.47) under the above conditions. Similarly, the short-run size conforming to minimum average costs, $d(AC)/dy=0$, for the owner-operator (4.47) will be smaller than for the cash tenant (5.48).[4] The arrows at the bottom of the graph indicate output magnitudes that conform with minimum average costs in this short-run context.

The marginal cost function (as well as the average variable cost function) will be the same for owner and cash tenants but lower than for the share tenant. However, if the share tenant pays only half the cost of variable inputs (since $r=.5$ and then $r=s$), the marginal and average variable cost functions for the share tenant, cash tenant, and owner-operator will be the same. This change creates the average cost function denoted by AC_s' in Figure 1 whose minimum is at an output still different from that for cash or owner conditions. While the new minimum cost point is at a larger short-run size (3.16) than formerly (2.24) for the share tenant, it is still a smaller size (Y) than for the cash tenant and owner-operator. While, in terms of profit maximization, share-rented (with $r=s$), owner-operated and cash-rented farms would operate at the same output level (i.e., short-run optimal size would be identical since the marginal cost function then is $d(TC)/dY=10Y-10$ and the three tenant forms have the same short-run supply function), the functions still differ in short-run size (Y) to give minimum costs. Hence, if the short-run condition were converted institutionally into a "long-run" situation, as by placing an upper or given size or acreage through legislation as is done in some countries, the play of competitive market forces (through resource prices, including land and its rental rate, and commodity supplies and prices) would cause average revenue to equal average cost at different sizes of output (i.e., different long-run equilibrium sizes) under the three tenure conditions. A country of owned farms would have "medium-sized" equilibrium units; one of cash-rented farms would have "large-sized" units; and the country of share-rented farms (with

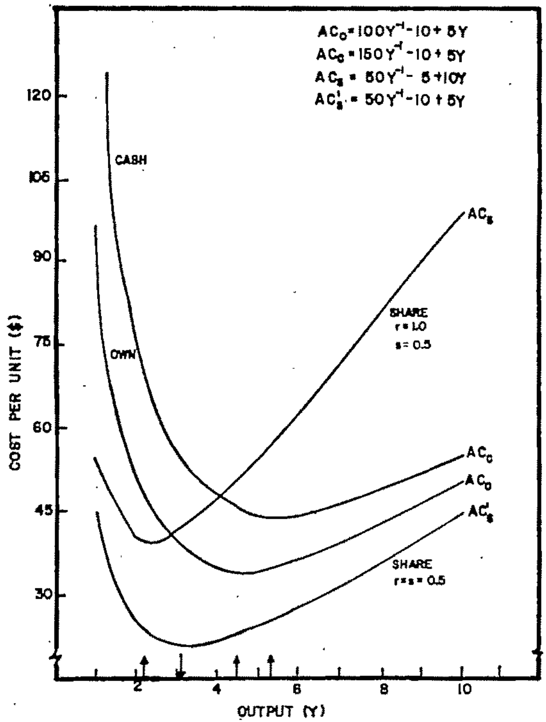

Figure 1. Cost functions and size for minima under different tenure forms

[4] While a specific algebraic form is used here, the condition is general for a short-run cost function where diminishing marginal productivity prevails for the variable factors and the fixed factor entails a higher outlay for the cash tenant and a lower outlay for the share tenant than for the owner-operator. The relative height of the functions and the slopes of the curves will, of course, vary with the relative magnitude of fixed and variable components of the cost function (i.e., on the nature of the production function and the prices of the different resources.)

tenants making the decision since, except in our illustration, the minimum point on the average cost function would be still different for the land owner) would have "small-sized" farms. In practice, of course, a wide range of these conditions prevail with custom, history, and institutions even restraining the acreage size. Hence, it is little wonder that farms vary so greatly in size and seem to survive equally in countries of mixed tenure systems.

Sizes Under State, Individual, and Cooperative or Group Structures

Another set of differing conditions under which farms of the world operate are those of individual, state, and cooperative (collective) organization. Farms of cooperative and state organization are typically large; those of individual organization are typically smaller. We now pose the question of which size is optimal under these three structures relative to certain implied objective functions. For purposes of simplicity, we assume the individual farm is owner-operated. Since the optimal size is identical for state and individual farms operated under the same production function, relative prices, and objective functions, we compare optimal sizes for individual and cooperative or group farms. We assume that the objective of the individual (state) farm is to maximize return or profit relative to the operating unit composed of all resources. For the group (cooperative or collective) farm composed of many members, we suppose the common and usually implied objective of maximizing return per member. We again use a "pure case" abstraction because space restrains discussion of all variants. The pure case assumes the same production functions and prices or weights. It also assumes that the cooperative members do not pay themselves a wage but organize the farm (select a size or investments) to maximize return per member.

For the sake of convenience and clarity, we initially assume a farm with the long-run production function in (17). Domar has discussed some conditions of equilibrium under classical, general conditions [2]. We provide our analysis relative to a range of forms in production functions which could prevail in the long run and short run. Since we first consider a long-run production function (all resources variable and increased in the same proportion), we can express the function in terms of one resource category. The nature of the production function is extremely important with respect to the organization of agriculture. If constant returns to scale prevail, there is no limit to optimal firm size, and the existence of extremely large-scale state and collective farms in Eastern Europe and the smaller family farms of Western Europe and North America are not inconsistent. Unfortunately, empirical scale studies are not widely available in any of these world regions (and less so in Eastern Europe) to indicate which conditions prevail. Without this knowledge, we initially assume the production function in (17) which has ranges of both increasing and decreasing returns to scale.

$$Y = aR + bR^2 - cR^3 \tag{17}$$

We use Y to denote output and R to denote resource input. (We suppose $R = r_1X_1, \cdots r_jX_j, \cdots r_{n-1}X_{n-1}$ where X_j is an individual resource, r_j is the proportion in which this resource is combined with R and all inputs are increased in these fixed, r_j, proportions). We may suppose R is labor and the X_j are the $n-1$ other resources. Hence, the function can be expressed as in (17) because all other resources are increased in the same proportion. We let X represent the aggregation ($X = r_1'X_1, \cdots r'_jX_j, \cdots r_{n-1}'X_{n-1}$) of other inputs held in fixed proportion. Hence, we have the two input prices P_r for labor and P_x as the aggregate price of other resources ($P_x = r_1'P_1, \cdots r_j'P_j, \cdots r_{n-1}^1P_{n-1}$). The private farm pays a price for all resources and has the objective or profit function:

$$\begin{aligned} \pi &= P_yY - (P_r + \alpha P_x)R \\ &= P_y(aR + bR^2 - cR^3) - (P_r + \alpha P_x)R \end{aligned} \tag{18}$$

where α is the ratio in which the aggregate resource X (nonlabor) is used with respect to R (labor). (A state farm will have the same objective function if it pays a price for all resources.) If we assume the objective for the group or cooperative farm is to maximize returns for its members (R or labor as the reflection of the member), its objective function is

$$\begin{aligned} \phi &= (P_yY - \alpha P_xR)R^{-1} \\ &= [P_y(aR + bR^2 - cR^3) - \alpha P_xR]R^{-1} \end{aligned} \tag{19}$$

In the cost term, we include only P_x or the price of the aggregate nonlabor resources (used in α proportion to labor) since the members do not pay the labor wage, P_r, to themselves but expect to get the return for their labor wage, P_r, along with other returns above fac-

tor costs from the proceeds of the farm firm. Since the objective of this "true cooperative" is to maximize return per member, we divide the difference of revenue and nonlabor costs by the amount of labor (i.e., multiply it by R^{-1} where R is the number of members or workers). Maximization of the objective (profit) for the individual farm is denoted by equation (20) where marginal profit (the derivative of equation (14) with respect to R) is equated to zero.

$$(20) \quad P_y(a + 2bR - 3cR^2) - P_r - \alpha P_x = 0$$

Maximization of the objective for the "pure cooperative" farm is denoted by equation (21) where the marginal labor return (the partial derivative of ϕ with respect to R in equation (19) also is equated to zero.

$$(21) \quad P_y(b - 2cR) = 0$$

Now, solving for the value of R in (20) and (21) to determine the optimal magnitude of labor input and farm size (since $R = \cdots r_jX_j \cdots$) for individual and cooperative farms, we obtain the values in (22) and (23) respectively.

$$(22) \quad R = .33bc^{-1} + [.33ac^{-1} - (P_r + \alpha P_x)(3cP_y)^{-1} + .109b^2c^{-2}]^{.5}$$

$$(23) \quad R = .5bc^{-1}$$

Several conditions are of interest. First, we note that the optimum size (the magnitude of R since $R = \cdots r_jX_j \cdots$) for the pure cooperative is not related to prices of output or nonlabor inputs. (The values of P_y and P_x do not occur in equation (23).) As indicated in (19), the magnitudes of P_y and P_x do affect the magnitude of returns per cooperative member, but they do not affect the optimum size or number of members (R) in (23). In other words, if P_y is higher (P_x is lower), cooperative members will have a higher income, but the same size is optimal regardless of prices. In contrast, the optimal volume or size for the individual farm (also a state farm under conditions specified previously) is a function of all prices. Optimally, it will be larger as output price increases and input prices decrease, or small under converse magnitudes of these prices. In the short run, the optimal individual farm would always be as large or larger (R will be greater) than the pure cooperative, the extent depending on P_y, P_r, and P_x.

Under classical long-run market equilibrium, however, the individual farm would have the same size as the optimal cooperative farm. The optimal pure cooperative farm size is that in equation (23), regardless of short-run or long-run conditions. Under long-run competitive market conditions, individual firms are expected to produce a volume denoting the minimum point on their long-run cost function. As is known for production function (17), this is the input level where the average productivity of resources is at a maximum. Hence, if we compute the average productivity function of R (divide equation (17) by R), and other resources (since $R = \cdots r_jX_j$) then take the derivative of Y with respect to R (and market equilibrium), the optimal size of the individual farm is identical with the universal size of the cooperative farm. But under no circumstances is the optimal size for the pure cooperative farm larger than for the individual farm.

Other Production Functions

We have provided results under a "general" production function. However, other production functions may prevail in agriculture, and we shall now examine two of these. Suppose we have a production function that (a) involves "set-up costs" in terms of resources (a minimum of resources is required before any output is attained and while k is negative, the meaningful value of the function begins at $Y=0$ and $R>0$) and (b) has diminishing marginal resource productivity as illustrated in (24).

$$24) \quad Y = -k + aR - bR^2$$

The corresponding objective functions, as characterized previously, are (25) and (26) respectively for the individual and pure cooperative farms.

$$(25) \quad \pi = P_y(-k + aR - bR^2) - (P_r + \alpha P_x)R$$

$$(26) \quad \phi = [P_y(-k + aR - bR^2) - \alpha P_xR]R^{-1}$$

Taking the first derivative of each equation, equating it to zero, and solving for the value of R, we have the optimal size of the individual farm in (27) and the optimal size (number of members) of the "pure cooperative" farm in (28).

$$(27) \quad R = .5ab^{-1} - .5b^{-1}P_y^{-1}(P_r + \alpha P_x)$$

$$(28) \quad R = (kb^{-1})^{.5}$$

Again, it is apparent that the optimal size (i.e., the value of R) for the pure cooperative farm is invariantly of this specified size regardless of price magnitudes. The optimal size of

the individual farm again is a function of both output and input prices and in all short-run cases where profit is greater than zero, it will have an optimal size larger than the pure cooperative.

We now examine the production function in (29) with marginal resource productivity constant at β. We suppose there is a natural endowment amounting to e (some "wild or natural product" is available regardless.)[5]

$$(29) \qquad Y = e + \beta R$$

The objective functions for private and pure cooperative farms are those respectively in (30) and (31).

$$(30) \qquad \pi = P_y(e + \beta R) - (P_r + \alpha P_x)R$$

$$(31) \qquad \phi = [P_y(e + \beta R) - \alpha P_x R]R^{-1}$$

The derivative of (30) is a constant, indicating that if the objective function of the private farm is greater than zero, $\beta > (P_r + \alpha P_x)P_y^{-1}$, there is no limit to its optimal size. However, for the pure cooperative objective function in (31) the value of ϕ declines positively for all values $R > 0$ (i.e., it is "meaningfully" maximum at $R = 0$). Hence, the pure cooperative would be as small as possible and if R represents members (labor) who must exist in integer values, the farm would be a "one-man" cooperative.

Other Implications

This paper establishes certain implications of optimization to firm size under alternative tenure forms. In a sense it provides hypotheses about reality which should now be empirically verified. The objective is not, however, to explain the political, social, market, and other forces that actually determine farm size in countries with contrasting social systems and at various stages of economic development. Farms that are both larger and smaller than the optimal specified under the criteria of this analysis may prevail entirely because of noneconomic objectives.

Later studies should deal with the economic and noneconomic forces that provide positive explanations of farm size. In the space available for this paper, we have not explored important variants such as fixed supplies of some resources for the firm, absence of resource markets and prices, limited managerial resources which may cause certain types of scale economies and special merits of large units, differences in opportunity costs of capital for managers under different tenure forms, or objective functions that (a) differ between the cooperative and its individual members with their private plots and (b) maximize rent to the state rather than returns to members. These and other considerations should be brought into empirical or qualitative studies directed at explaining differences in farm size, between "capitalist" and "socialist" countries or between "developed" and "undeveloped" countries.

We hope that the discussion will go forward from this modest fundamental contribution to related problems which should be treated theoretically and quantitatively. For example, in the context of factor markets or relative scarcities and stages of economic development, larger farms in the East and smaller ones in the West also seem inconsistent (other social and political considerations aside). The reasoning is as follows, using production function (1) as a reference point: The least-cost combination of resources is denoted under the condition $\partial X_1/\partial X_j = P_j/P_1$ where P_j and P_1 are the respective prices or weights (reflecting and relative scarcities) of factors j and 1. If j denotes capital and 1 denotes labor, the optimal ratio of labor to capital will be smaller as the price of capital declines relative to the price of labor. Capital real price is lowest relative to labor at advanced stages of economic development and highest at lower stages of development. Countries at lower stages of development optimally should have a "high" ratio of labor to capital and those at higher stages of development should have a "low" ratio. However, as a greater amount and ratio of capital is used, the fixed costs of farming increase and the cost function declines over a greater magnitude of output (i.e., the minimum on the cost function occurs with a larger farm). In this context, since they are at a somewhat higher stage of economic development (the supply of capital

[5] If the production involved the "set-up" costs in (24) but otherwise was linear (i.e., if the term bR^2 were left off the function), there would be no limit to the optimal firm size for the individual farm if $a > (P_r + \alpha P_x)P_y$. Similarly, the average return per member (worker) on the cooperative farm would increase continuously with the magnitude of R, but a mathematical limit in return per worker (and thus in optimum size) is approached at the value $aP_y - \alpha P_x$ (the asymptote of average return is $aP_y - \alpha P_x$). If the function were $Y = e + aR - bR^2$, there would be a limit in optimum size for the individual farm, but as for (29) the pure cooperative farm would be "as small as possible" for a positive value of R.

is greater relative to the supply of labor), countries of Western Europe and North America should have a larger optimal farm size than countries in Eastern Europe. Since the opposite condition prevails and our previous analysis suggests that cooperative farms would never have an "individual optimal size" larger than a private farm (ceteris paribus), we have further reason for suggesting that more attention should be directed towards the analysis of optimal farm size under different tenure, social developmental structures.

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Allocative Efficiency, Traditional Agriculture, and Risk*

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A decision theory approach is presented for the assessment of allocative efficiency from cross-section production function estimates. Reappraisal of some of the evidence previously adduced gives only mixed support to the hypothesis of profit-maximizing behavior by farmers in traditional agricultures. It is suggested that scope remains for investigation of the alternative hypothesis of utility maximization which, unlike profit maximization, explicitly allows for subjective risk considerations and might therefore provide a more realistic basis for policies aimed at the modernization of traditional agricultures.

WITH allocative efficiency defined in terms of profit maximization, T. W. Schultz's hypothesis that "there are comparatively few significant inefficiencies in the allocation of the factors of production in traditional agriculture" [20, p. 37] has been a topic of substantial interest in recent years. Major empirical studies relevant to the hypothesis have been the cross-sectional production function analyses of Chennareddy [2], Hopper [7, 8], Massell [10, 11], Massell and Johnson [12], Sahota [17], Welsch [22], Wise and Yotopoulos [24] and Yotopoulos [25, 26]. With the exception of Massell, whose presentation is noncommittal, these authors have concluded that their analyses support the hypothesis of profit-maximizing behavior in traditional agricultures.

Excluding the work of Wise and Yotopoulos, which constitutes a special case since it is oriented to individual firms rather than to the average sample firm, none of these studies has presented a test of *economic* merit or validity relative to Schultz's hypothesis. We believe more pertinent economic appraisals of the data relative to the average cross-sectional firm are possible and illustrate such an appraisal via some of the data previously adduced as supporting the hypothesis of profit maximization. Our reappraisal of these data provides only mixed support for the profit-maximizing hypothesis. The way is thus left open for investigation of alternative hypotheses—in particular, the hypothesis of allocative efficiency based on (expected) utility maximization in the face of subjective risk. Some discussion of this utility analogue of Schultz's hypothesis is presented after our reappraisal of the evidence for profit maximization.

The Usual Approach to Measuring Profit Maximization

The typical approach [2, 6, 8, 17, 22, 25] to judging efficiency in cross-sectional samples has been to estimate a Cobb-Douglas type production function and then, using point estimates of the production elasticities, to make some statistical sampling theory test of equality between the estimated single-valued marginal value products and marginal factor costs of the geometric mean firm. Such sampling theory tests then form the basis of statements like "All the [twelve] ratios except three are not significantly different from 1.0, indicating that available evidence does not lead to rejection of the hypothesis of production efficiency . . . Three of the ratios are significantly different from 1.0, . . . but two of them are significantly different from 1.0 only at the 10-percent level" [2, p. 891].

Such statements, based on the mechanical use of traditional significance levels, are devoid of economic content [5, Ch. 9; 18, Pt. 5]. In our view significance tests based on arbitrary probability levels are irrelevant to economic problems and provide no basis for the assessment of allocative efficiency. What is needed is a measure of profit-maximizing efficiency that has a direct economic interpretation yet depends on the statistical quality of the underlying production function estimate.

An Economic Approach to Measuring Profit Maximization

In essence, our approach for measurement of the degree of profit maximization is analogous to the use of opportunity loss functions in statistical decision theory [5, 27]. Given an estimate of a Cobb-Douglas production function, this approach involves estimating the expected opportunity loss of a producer who

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operates with the sample geometric mean combination of inputs rather than with the estimated most profitable combination of inputs. Recognizing the constrained situation under which producers generally operate, following Duloy [4] we define the optimal allocation as a fixed-outlay constrained optimum with the constraint set at the financial sum of the geometric mean resources. In other words, we examine the expected opportunity loss of the average input allocation relative to the most profitable allocation that is feasible with total expenditure unchanged.

As in the usual approach to measuring allocative efficiency, we take prices, technology, and entrepreneurial services as fixed and ignore the fact that these may vary among farms. Likewise, our analysis relates only to the average sample farm. As Massell and Johnson emphasize [12, p. 53], profit-maximizing resource use on the average farm is a necessary but not a sufficient condition for profit-maximizing behavior on individual farms. Concomitantly, any failure to meet profit-maximizing conditions on the average farm implies at least some failure to meet profit-maximizing conditions on an individual farm basis.

Consider the regression-based Cobb-Douglas type production function estimate from a cross-sectional sample:

$$Y = b_0 \Pi X_i^{b_i} \tag{1}$$

which relates income Y to the inputs X_1, $X_2, \cdots X_n$, each b_i being the best linear unbiased estimate of the population elasticity β_i. Costs of the inputs are introduced through the profit function:

$$\pi = Y - \Sigma c_i X_i \tag{2}$$

where c_i is the unit price of X_i.

Opportunity loss L incurred by nonoptimal operation of the average firm is defined as

$$L = \tilde{\pi} - \bar{\pi} \tag{3}$$

where $\tilde{\pi}$ and $\bar{\pi}$ denote respectively the profit computed at the optimal and geometric mean input levels (denoted by $\tilde{X}_i$ and $\overline{X}_i$ respectively). Since optimal operation is constrained to employing only the geometric mean total of resource outlay (i.e. $\sum c_i\tilde{X}_i = \sum c_i\overline{X}_i$), this opportunity loss can be expressed as

$$L = b_0(\Pi \tilde{X}_i^{b_i} - \Pi \overline{X}_i^{b_i}). \tag{4}$$

The loss L will be zero if $\overline{X}_i$ equals $\tilde{X}_i$ for all i, and positive otherwise.

The measure by which we propose judging efficiency of resource use is the expectation of the opportunity loss L when account is taken of the fact that the production coefficients b_i are probabilistic estimates based on data from a cross-sectional sample reflecting nonhomogeneity due to variations in resource endowments, weather effects, and managerial services and attitudes. Thus the question we pose is: What is the expected opportunity loss suffered by a geometric mean producer relative to the expected profit he would achieve if he were to operate at the constrained optimal input levels implied by the b_i, given that these b_i are only sample estimates and have some associated probability distribution?

For any estimated production function, the loss L is a function of the random variables b_i denoted by $L(b_1, b_2, \cdots b_n)$. If we denote the joint probability distribution of the b_i's by $f(b_1, b_2, \cdots b_n)$, the expected loss is

$$EL = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\cdots\int_{-\infty}^{\infty} L(b_1, b_2, \cdots, b_n) \cdot f(b_1, b_2, \cdots, b_n)\,db_1 db_2 \cdots db_n. \tag{5}$$

Because of the algebraic form of $L(b_1, b_2, \cdots b_n)$, it is computationally most expedient to estimate EL by Monte Carlo evaluation of the integral of equation (5) using pseudorandom sampling from the appropriate multivariate distribution of the b_i's. That is, a sample of b_i's is drawn at random, the associated loss computed as in equation (4), and this procedure repeated many times so that the average of these losses approaches EL stochastically. Following the usual assumptions, the multivariate normal is suggested with the proviso that variates are truncated symmetrically so that sampled b_i's are strictly positive, as is required by economic theory. Empirical work indicates that 1,000 replications of the Monte Carlo procedure are sufficient to provide a stable estimate of EL.

An index by which the degree of nonattainment of profit maximization by the average firm may be subjectively assessed is given by the ratio of expected loss to expected optimal profit, i.e., $EL/E\tilde{\pi}$ $(=EL/[EL+E\bar{\pi}])$. The greater the divergence of this ratio above or below zero, the greater the degree of inefficiency implied by operation at geometric mean input levels.[1] Multiplying the absolute value of the

[1] Just what size index of inefficiency should be interpreted as implying significant nonattainment of profit maximiza-

ratio by 100 gives the percentage of potentially achievable profit foregone through failure to allocate resources optimally in terms of profit maximization.

Some Evidence Reexamined

Because the published studies of interest [2, 8, 10, 11, 12, 17, 22, 25, 26] do not report the covariance matrix of the b_i's and because our further attempts to obtain this information were unsuccessful, it was necessary to simplify equation (5) by using the marginal probabilities of the joint distribution of the b_i's. This is equivalent to assuming that the distributions of the individual b_i's are independent.[2]

A further difficulty was that some or all of the required data concerning prices and geometric mean input levels were not available for the studies of Massell [10, 11] and Welsch [22] so that reappraisal of these studies was not possible. Likewise, it was decided not to reprocess Sahota's [17] functions because of the number of variables and production functions involved and because of some doubts about the underlying data which (unlike that of the other studies) were not collected specifically for the purpose of testing the hypothesis of profit maximization. Our reappraisal of the evidence therefore relates only to the samples of Chennareddy [2] for South India; Yotopoulos [25, 26] for northern Greece; and on an enterprise-by-enterprise basis, Hopper [8] for North Central India.

Chennareddy data

Three production function estimates were presented by Chennareddy in support of the profit-maximizing hypothesis. They relate to farms in the West Godavari district of South India: one for a sample of 67 rice farms, one for 37 tobacco farms, and a "district" function based on aggregation of the rice and tobacco samples. The input categories were land, labor, capital, and operating expenses.

Table 1. Expected loss and index of inefficiency of operation at average input levels for three South Indian production functions[a]

	Sample		
	Rice	Tobacco	District
Expected loss, EL (Rs.)	265.5[b]	2,757.3	238.5
Index of inefficiency, $EL/E\bar{\pi}$	0.13[b]	0.28	0.10

[a] Chennareddy [2].
[b] With nonland capital held at its mean level.

Table 1 lists the results of our analysis. The prices used were those specified by Chennareddy. Because of the very poor estimate of the coefficient for nonland capital in the rice sample function (0.0001 with standard error 0.0482), nonland capital was held fixed at its geometric mean level in calculating expected loss for the rice sample. Thus the estimate of expected loss for rice must be regarded as only a partial estimate, since it assumes one of the production coefficients to be known perfectly and therefore underestimates potential expected loss. Too, because of the influence of the rice sample component, the capital coefficient in the district function (0.0007 with standard error 0.0273) is rather unreliable, so that the results for the tobacco sample must be regarded as the most reliable of the three efficiency analyses. Given these provisos, the expected losses of Rs. 265 and 238 and indexes of inefficiency of 0.13 and 0.18 for the rice and district functions, respectively, imply fair correspondence with the hypothesis of profit maximization. The reverse applies to tobacco and suggests a conclusion rather different from that drawn by Chennareddy. For the tobacco sample he found that none of the MVP/MFC ratios differed significantly from unity at the five percent level and concluded that resources were allocated in profit-maximizing fashion.[3] With an index of inefficiency of 0.28, implying an expected opportunity loss equal to 28 percent of potentially achievable expected profit, we are forced to draw the alternative conclusion that allocative efficiency in this traditional agriculture is low in terms of profit maximization.

tion is a matter of subjective judgment. No standards of comparison are yet available. Personally, we feel that an index greater than $|0.2|$ (i.e., more than 20 percent of potentially achievable profit foregone) may reasonably be interpreted as indicating poor allocative efficiency with respect to profit maximization. Others may differ in their judgment.

[2] The extent and direction of bias in estimates of EL resulting from the assumption of zero covariances between the b_i's depend on several factors including the correlations among the independent variables. Often the variables will be positively intercorrelated, in which case the covariances between the b_i's will tend to be negative so that a failure to account for covariance may tend to overestimate EL. The extent of overestimation will depend on all the numerical features of a production function.

[3] The ratio for district capital in Chennareddy's Table 2 [2, p. 819] is misprinted; it should read 0.071.

Yotopoulos data

The evidence presented by Yotopoulos relates to a sample of 430 subsistence farmers in the Epirus region of northern Greece. His study, by far the most thoroughgoing of those so far addressed to the efficiency of traditional agriculture, is comprehensively described in [25]. Analysis pertinent to the hypothesis of profit maximization is summarized in [26].

Yotopoulos hinges his discussion of profit-maximizing efficiency on his Cobb-Douglas function *R*2 [26, p. 129], which includes an education variable and combines data from both large and small farms. He finds land and labor to be allocated very efficiently on the average farm. The position with regard to the three capital input classes and the education variable is not so clear. The difficulties in assessing capital use arise from the definitions of the service flows used to measure capital inputs. These make pricing of these inputs somewhat ambiguous [26, p. 131]. It seems likely that the true opportunity cost of capital lies within the range of 1.05 to 1.15 drs. per dr. Assuming a cost of 1.10 drs., the allocations of plant and equipment capital seem quite efficient in conventional terms, and the use of live capital rather less efficient. Efficiency in the use of education could not be assessed because of the lack of data on its marginal cost. Overall, Yotopoulos [25, Ch. 11; 26, p. 133] concludes that the traditional agriculture of Epirus is "poor but efficient."

In our reexamination of his data, we used Yotopoulos' function *R*2 with education held fixed at the sample geometric mean level, thereby treating one of the coefficients as known perfectly with a consequent reduction in potential expected loss. The marginal costs assumed for labor and land were 29 drs. and 90 drs. respectively as per Yotopoulos [26, pp. 130–1]. Because of difficulties already noted in pricing capital, three values were used: 1.05, 1.10, and 1.15 drs. per dr. Our results, listed in Table 2, are quite insensitive to the capital price variations considered. They indicate that the average Epirus farmer was sustaining an expected opportunity loss equal to eight percent of his potentially achievable expected profit. This result well supports the hypothesis of profit maximization in the traditional agriculture of Epirus.[4]

[4] In further analysis of Yotopoulos' data, using a model that allows for interfirm variation in productivity and prices, Wise and Yotopoulos [24] have found that on an individual (rather than average) farm basis, two-thirds of the variance in input use could be explained by profit maximization. They do not mention the alternative hypothesis of expected utility maximization.

Table 2. Expected loss and index of inefficiency of operations at average input levels for a Greek production function[a] under three costs of capital

	Cost of capital[b]		
	1.05	1.10	1.15
Expected loss, *EL* (drs.)	1,131	1,090	1,206
Index of inefficiency, $EL/E\bar{\pi}$	0.08	0.08	0.08

[a] Yotopoulos [26].
[b] Drachmas per drachma.

Hopper data

Based on a sample of 43 farmers in an Uttar Pradesh village, Hopper [8] estimated separate production functions for their dry season barley, wheat, pea, and gram enterprises. These crops are highly competitive in their demands for the farmer's inputs of land, labor, bullock time, and irrigation water. Data on input use were meticulously collected relative to each crop. In terms of economic appraisal, an inherent difficulty was the poor definition of the factor markets—particularly for land, bullock time, and irrigation water. These difficulties were noted by Hopper [8] and by Schultz [20, pp. 44–48] who, in advocacy of his hypothesis, made extensive use of Hopper's results.

Following Hopper [8, p. 621], labor was priced at Rs. 0.068 per hour in our reappraisal, and, in the absence of a well-defined market for irrigation water, a 750-gallon unit was costed approximately [8, p. 623] at Rs. 0.5. For the price of bullock time we used Rs. 0.76, the implicit equilibrium price estimated by Hopper [8, p. 621]. Choice of an annual charge for a "standard" acre presented more difficulty since the tenants' payment for land typically consisted of a cash rent plus a variety of nonmonetary "understandings," such as the provision of labor when required by the landlord [8, p. 622]. We straddled the likely range of annual land price by using prices of Rs. 13, 36, 45, 59, 83 and 106. Rs. 13 corresponds to the average annual cash rent for a standard acre, as reported by Schultz [20, p. 95] from Hopper [7].

Rs. 106 corresponds to an interest rate of 4.5 percent on the market value of a standard acre. Based on these input prices, the expected losses of a geometric mean producer for each of Hopper's estimated production functions are summarized in Table 3 and Figure 1.

As Figure 1 shows, minimum expected loss for each crop enterprise considered independently[5] occurs at a land price of Rs. 36 for peas and at Rs. 45 for barley, wheat and gram. Except for the pea enterprise, these loss minimizing prices are consistent both with each other and with Hopper's alternative point estimates of Rs. 44 and 48 for the implicit equilibrium land price [8, pp. 620–1]. If the actual average price of land were in fact Rs. 45 and our other assumed prices were equilibrium (i.e., loss-minimizing) prices for the average firm, then our analysis would strongly support Schultz's hypothesis. We do not, however, know the price paid for land and, as Figure 1 shows, the assumed prices for other factors can not be equilibrium prices relative to geometric mean input levels since they do not permit an expected opportunity loss of zero. For these reasons the inefficiency indices of Table 3, indicating expected opportunity losses at best of only 6 to 11 percent of potentially achievable profit, must be regarded cautiously. All that can be said from our analysis is that the possibility of profit-maximizing behavior by the average producer is not disproved. Such would have been the case if the expected loss-minimizing land price had differed markedly among the four crops (given their competitive demand for resources) and if expected losses at these prices had been close to zero. Thus, because of the lack of definition of the factor markets, our reappraisal of Hopper's data is inconclusive. The same difficulty, however, is also implicit in the analyses of Hopper [8] and Schultz [20, pp. 44–48].

[5] Independent assessment based on a fixed outlay constraint for each crop rather than interdependent assessment of all four enterprises with only an overall constraint on outlay [3, pp. 60–2] was used so as to obtain the implicit loss-minimizing land price for each crop.

Table 3. Expected loss and index of inefficiency of operation at average input levels for four Central Indian production functions[a] under three land prices

	Enterprise			
	Barley	Wheat	Pea	Gram
Land price = Rs. 13				
Expected loss, EL (Rs.)	168.1	49.6	144.2	41.1
Index of inefficiency, $EL/E\bar{\pi}$	0.21	0.14	0.22	0.15
Land price = Rs. 45				
Expected loss, EL (Rs.)	79.2	23.8	72.4	18.8
Index of inefficiency, $EL/E\bar{\pi}$	0.09	0.06	0.11	0.06
Land price = Rs. 106				
Expected loss, EL (Rs.)	119.5	50.8	138.2	43.1
Index of inefficiency, $EL/E\bar{\pi}$	0.15	0.14	0.20	0.14

[a] Hopper [8].

Utility Versus Profit Maximization

Our reappraisal of some of the evidence, using an economic (decision theory) rather than a statistical (significance testing) criterion of profit-maximizing efficiency, gives only mixed support to the hypothesis of profit-maximizing behavior by farmers in traditional agriculture. We find Yotopoulos' data relatively favorable to the hypothesis, Hopper's data inconclusive, and Chennareddy's data relatively unfavorable.

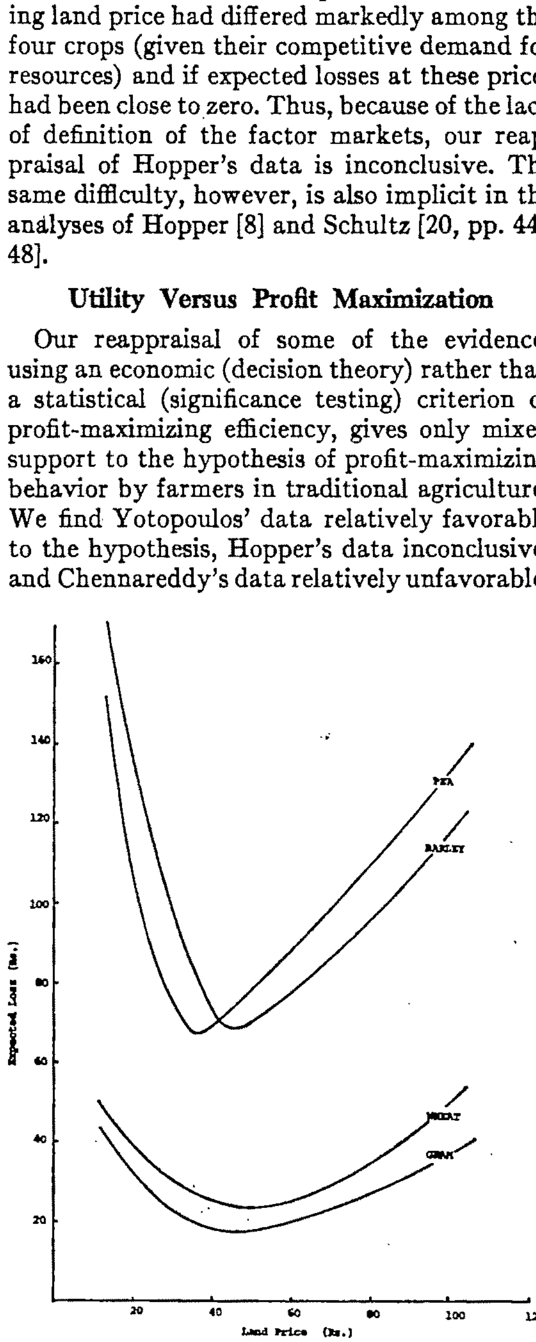

Figure 1. The effect of varying price of land on expected losses for four Central Indian production functions

Nonetheless, our results are more favorable to the hypothesis of expected profit maximization than we would have expected. Personally, we would hypothesize that farmers in traditional agriculture (and elsewhere) typically have nonlinear utility functions (implying active consideration of subjective risk) and successfully endeavour to maximize expected utility[6] rather than expected profit. Such a hypothesis would be compatible with our results if it could be assumed that the average Epirus farmer had a nearly linear utility function and saw himself as facing little risk. But there is no available evidence to support such assumptions. In contrast, no special assumptions are needed in suggesting that our analysis of the Chennareddy and Hopper data leaves the way open for investigation of the alternative hypothesis of utility maximization.[7] Some comments on the utility hypothesis are therefore pertinent, particularly since the usual literature on agricultural development (e.g. [13, ch. 16; 14, 19, 20]) advocates the profit-maximizing hypothesis and contains only passing comment on risk considerations. Moreover, these comments are generally qualitative, invariably emphasize risk aversion, ignore utility, and are largely based upon introspection. The same is true of the limited literature specifically concerned with risk in underdeveloped agricultures.[8]

So far as we are aware, the quantitative evidence on the role of risk in traditional or developing agricultures is very limited. Behrman [1, ch. 10], in his study of Thai crop supply response, found negative response in aggregate to increasing risk. In a recent unpublished study of the utility functions of producers in the traditional wool-growing industry of the Australian pastoral zone, Francisco and the authors found 20 members of a sample of 21 producers to have nonlinear utility functions, 3 of which exhibited risk preference. Vicente [21], in a study of 47 Chilean farmers' utility functions over the range of money gains to three times their annual net income, found only 4 functions to be approximately linear and 12 to exhibit strong risk preference.

Though probably explainable in the context of the state-financing and uncertainty surrounding the Chilean land reform, the extent of risk preference found by Vicente is particularly interesting. It runs counter to the accepted wisdom about risk found in much of the agricultural development literature, e.g., [13, 14, 20, 23]. This wisdom runs somewhat as follows (overlooking the inconsistency of implying both profit and utility maximization): (1) traditional agriculture is efficient in a profit-maximizing sense; (2) development necessitates new techniques and inputs; (3) new techniques and inputs are viewed by farmers as risky; (4) farmers are risk averse; (5) risk is therefore an important impediment to development. Such a line of argument may overemphasize risk aversion. Attitudes to risk, as measured by the degree of preference or aversion, will vary both among farmers and, for one farmer, among different levels of expected profit. We would hypothesize that risk is not a negative influence for all producers and that attitudes of risk preference may have, for example, played an important role in catalyzing the recent rapid adoption of new crop varieties in some parts of Asia.

Finally, despite the mixed results of our reappraisal of the Chennareddy, Hopper, and Yotopoulos data, in our view quantitative information on risk attitudes must be an important element in understanding farmer behavior in underdeveloped agricultures and, ipso facto, in the generation of policies for their modernization. Such quantitative information could be readily obtained via the estimation of farmers' utility functions [9, 15]. At the same time, as suggested by Wharton [23], much more attention should also be given to quantitative assessment of the subjective risks seen by farmers in underdeveloped agricultures. With better knowledge of both farmers' attitudes to risk and the risks they see themselves facing, it should be possible to formulate more efficacious development policies. Such opportunities could be lost if the hypothesis of profit maximization is accepted without qualification.

[6] This hypothesis is not new. It was argued more than a decade ago by Porter [16] in a theoretical paper concerned with risk aversion as an impediment to technical change in Indian agriculture. Porter also explored in some detail the possible policy implications of the expected utility hypothesis. Regrettably, this work appears to have been overlooked in more recent analyses of efficiency in traditional agriculture.

[7] Testing of the utility hypothesis is likely to be difficult since each producer must be postulated to have his own individual utility function and it makes no sense to talk of an aggregate or sample utility function. Appraisal would have to be on an individual producer basis, perhaps along the lines suggested by Officer and Halter [15].

[8] This literature has been noted in a comprehensive paper by Wharton [23].

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Economic Analysis of Irrigation in Subhumid Climate*

Oscar R. Burt and M. S. Stauber

An economic model is developed for analysis of investments in irrigation. The model encompasses the associated problem of temporal allocation of limited irrigation water within the growing season of a single crop. The problem is placed in the framework of stochastic dynamic programming, and it is shown how the algebraic form of the production function for the crop determines the appropriate state variables of the decision process. An application of the model is made to conditions prevalent in Central Missouri with corn the irrigated crop.

Recent technological developments have stimulated interest in the economic feasibility of irrigating field crops in relatively high precipitation areas. Intensification in the production process has taken place by increasing the levels of many factors while holding inputs of water constant at natural precipitation, which tends to increase the marginal productivity of water (assuming complementarity among the factors of production with water). Also, technological improvements in the methods of pumping and distributing water, as well as improvements in earth-moving equipment used to prepare irrigation sites and reservoirs, have extended the boundaries of economic feasibility. Consequently, an economic evaluation of the feasibility of investments in irrigation facilities in subhumid areas assumes increasing importance.

Irrigation development in subhumid areas is likely to be dominated by individual farm or relatively small community developments as contrasted to the large reclamation projects characteristic of arid regions. In subhumid regions, runoff from each farm is often adequate to provide supplemental irrigation water for the limited irrigable land on the farm, although there are many situations that could benefit from community-coordinated irrigation development where the runoff can be captured more efficiently for larger areas. Government may have a responsibility stemming from externalities associated with irrigation development, but the inherently small-scale investments will be left up to individuals or, at most, to small groups of farmers. However, subsidies such as those administered by the Soil Conservation Service might be important in motivating private development. Since most investment decisions on irrigation in subhumid regions will be made by the private sector, this study focuses on decision problems confronted by the individual or by a small group that functions essentially as a single decision unit.

The Investment Decision

Determination of an efficient investment policy in irrigation facilities can be viewed as ascertaining the optimal allocation of limited funds to the various investment categories comprising a workable irrigation system. More specifically, an investment model can be defined with three components, or variables, to which funds are devoted:

x = water storage capacity
y = distribution capacity
z = acres developed for irrigation

The net cash flow, or quasi-rent, associated with an investment and received in year t is denoted by $N_t(x, y, z)$, and initial cost of the investment is denoted $I(x, y, z)$. Replacement and maintenance costs are deducted in the definition of $N_t(x, y, z)$. This quasi-rent function, $N_t(x, y, z)$, is a critical measure for economic evaluation of investments in irrigation, and it is extremely difficult to estimate in subhumid climates. In the first place, quasi-rents are random variables with substantial variation, which suggests that $N_t(x, y, z)$ be defined as an expected value instead of actual quasi-rent. Also, there is implicitly an intraseasonal irrigation policy associated with the definition of quasi-rents. A major objective of this article is to develop and illustrate the methodology for deriving *optimal* irrigation policies, which are necessary to make an economic analysis of irrigation investments. Thus $N_t(x, y, z)$ is defined as an expected value measure and implicitly reflects an optimal irrigation policy for intraseasonal management of water, given an

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investment described by the magnitudes of x, y, and z.

If the money capital position of the firm is such that the present value criterion can be applied, the investment problem can be stated as

$$\text{(1)} \qquad \underset{x,y,z}{\text{Maximize}} \left[-I(x, y, z) + \sum_{t=1}^{T} N_t(x, y, z)/(1 + r)^t\right]$$

where T is the firm's planning horizon and r is the relevant discount rate. Terminal value of the investment at the end of the firm's planning horizon is included in $N_T(x, y, z)$. Necessary conditions for (1) to be a maximum are: marginal initial investment costs equal discounted marginal quasi-rents with respect to each variable. In some situations, or for simplification of the analysis, y may be uniquely determined for given values of x and z, which lets it be dropped from the problem as a decision variable.

More often than not money capital is limiting and its opportunity cost is unknown, or more specifically, the opportunity cost must be jointly determined with the optimal allocation of the limited funds. The internal rate of return is a useful guide in such circumstances. Let the limited capital for investment in irrigation be $\$C$. The decision problem is to allocate it among the three components x, y, and z so that the internal rate of return is a maximum. This is stated mathematically as the maximization problem of (1) subject to the constraint

$$\text{(2)} \qquad I(x, y, z) = C$$

and the auxiliary equation

$$\text{(3)} \qquad I(x, y, z) = \sum_{t=1}^{T} N_t(x, y, z)/(1 + r)^t$$

which determines r simultaneously with x, y, and z. The necessary conditions are expressed by the four equations: (2), (3), and the two equations in (4).

$$\text{(4)} \qquad \left[\sum_{t=1}^{T} \frac{\partial N_t}{\partial x} \Big/ (1 + r)^t\right] \Big/ \frac{\partial I}{\partial x} = \left[\sum_{t=1}^{T} \frac{\partial N_t}{\partial y} \Big/ (1 + r)^t\right] \Big/ \frac{\partial I}{\partial y} = \left[\sum_{t=1}^{T} \frac{\partial N_t}{\partial z} \Big/ (1 + r)^t\right] \Big/ \frac{\partial I}{\partial z}.$$

The two equations in (4) have the interpretation of equal ratios of discounted marginal quasi-rents to marginal initial investment costs among all pairs of investment components, x, y, and z.

For a given developed acreage and at a particular point in the irrigation season, either water supply as determined by x or distribution capacity, y, may limit the total amount of irrigation water applied. Distribution capacity will be a limitation predictable with certainty, but for a given storage capacity the water supply constraint will be a random variable when looking ahead more than one period at a time. Taking x and y as a composite dimension of the investment decision and acres developed, z, as the other variable, the critical question in the investment decision is whether to irrigate a few acres intensively or many acres extensively. When average precipitation is fairly heavy, but extremely variable as in most subhumid areas, this is not an easy question to answer. The intraseasonal irrigation policies applied under various levels of intensity of irrigation are indispensable in estimating the quasi-rent functions. The fact that very little research has been done to determine efficient intraseasonal irrigation policies may be a serious bottleneck in estimating the quasi-rent functions and thus objectively evaluating irrigation investments.[1]

Temporal Allocation of Irrigation Water

The temporal allocation problem to be discussed here exists under irrigation in arid as well as subhumid regions, but the analysis is more complicated in higher precipitation areas because of the increased importance of random precipitation. A significant amount of precipitation during the growing season of the crop accentuates the importance of a sequential decision framework that exploits all the information known at each point in time. The problem is to find a sequential decision rule that maximizes an appropriately defined objective function taking into account the stochastic nature of precipitation and other pertinent random weather inputs.

Bellman [1, 2, 3] has helped to develop the theory of multistage or sequential decision processes and has coined the term dynamic pro-

[1] Since this study was completed, there have been several other studies addressed to the problem of intraseasonal allocation of limited irrigation water [6, 10, 13]. The dissertations of de Lucia [6] and Dudley [10] also consider some aspects of the investment decision problem.

gramming to describe the methodology that will be used on the temporal distribution problem of irrigation water. Some basic concepts and definitions that are needed to understand dynamic programming procedures are discussed in the context of their general application to an irrigation problem. First, the decision process or economic activity is divided into time periods or intervals, called *stages*. The *state* of the process is another important concept. For crop irrigation, the state variables should describe the condition or productive potential of the crop and the availability of water stocks, both of which are dependent upon past weather conditions and irrigation treatments.

At each stage a set of relevant decisions or alternative actions exists concerning the amount of water to apply, if any. Selection of a particular alternative at a specified stage and state of the process will influence the state of the process in the following stage. This introduces the concept of *state transition*. Transition from one state to another can be with certainty, or it can be stochastic in nature. With supplemental irrigation the transition is stochastic, because of the uncertain nature of random weather inputs, such as precipitation and temperature, which influence crop condition and water stocks.

An optimal policy specifies the decision, for all possible combinations of states and stages, that will result in optimization of the criterion function. In the context of a supplemental irrigation process, the optimal policy would indicate the amount of water to apply at each time period, for all possible combinations of crop conditions and levels of water supply, in order to maximize expected net returns.

A general requirement must be placed on the criterion function in order to apply dynamic programming. This requirement, known as Markovian dependence [1, p. 54], states:

> After any number of decisions, say k, we wish the effect of the remaining N-k stages of the decision process upon the total return to depend only upon the state of the system at the end of the k-th decision and the subsequent decisions.

That is, at each stage the decision process is independent of earlier stages, provided the state of the process is given. This property in the context of an irrigation problem means that the state variables of the process must encompass the complete influence of all factors affecting the crop in previous stages; and for a given stage and state of the process, only the decisions in the current stage and future stages determine an optimal policy.

In many respects the greatest challenge in applying dynamic programming is to formulate a realistic model with the state variables defined in such a way that the Markovian condition is met and the number of state variables is small, preferably no more than two.

The temporal allocation problem, in its broadest framework, has two distinct parts: (1) intraseasonal or short-period allocation, which is always important; (2) interseasonal or annual allocation of water, which becomes less important under relatively high annual precipitation, when irrigation has the primary function of redistributing water within the year to increase production and total water during most years is adequate without carryover from preceding years. Of course, the importance of annual carryover is relative, and there is always a chance that carryover would be advantageous during some years even under very high average precipitation.

Only the first of these two allocation decisions is analyzed in this study, in which it is assumed that year-to-year carryover is relatively unimportant. The present model is also applicable when the water supply is ground water or a stream without storage, in which case the state variable for water storage is deleted from the model.

The simplifying assumption is made that additions to the storage reservoir during the irrigation season are negligible; or, as an approximation, expected additions to storage in that period are treated as if already in storage. This assumption should cause little concern when applied to subhumid areas such as eastern United States, because their irrigation season is both short and *relatively* dry compared with winter and early spring.

The crop production function

The algebraic form of the production function, which contains climatic and cultural variables as its arguments, determines the number and form of state variables used to describe crop condition at a particular stage of the decision process. For practical purposes the production function must not only be a good statistical fit; it must also be amenable to partitioning in the time dimension using only one or two state variables.

To clarify the nature of the problem, let us examine the Cobb-Douglas function with only water as an argument. The irrigation season is

divided into M discrete time periods, and water added to the soil during each period is a separate factor of production. Let irrigation water and precipitation be denoted, respectively, by u_j and v_j for the jth period of the season; and irrigation water is a net measure commensurate with precipitation so that a composite water variable, $w_j = u_j + v_j$, can be defined. The Cobb-Douglas function is written as

$$(5) \qquad Y = b_0 w_1^{b(1)} w_2^{b(2)} \cdots w_M^{b(M)},$$

where b_0 and $b(i)$ are parameters. The partial yield factor

$$(6) \qquad b_0 w_1^{b(1)} \cdots w_j^{b(j)}$$

summarizes the influence of water (irrigation and precipitation) received during the first j periods of the irrigation season. If we were given the above factor (6), we could compute yield for any set of water variables, w_{j+1}, $w_{j+2}, \cdots w_M$. In other words, (6) summarizes the influence of $w_1, w_2, \cdots w_j$ on yield with only a single measurement. That measurement could serve as a state variable in a dynamic programming formulation.

However, we could also use any monotonic transformation of the yield equation instead of the equation itself. A monotonic transformation permits a one-to-one correspondence between yield and the transformed yield. Thus, taking logarithms of both sides of (5) gives

$$(7) \qquad \log Y = \log b_0 + b(1) \log w_1 + \cdots + b(M) \log w_M.$$

All the influence of water on the crop through period j can now be summarized by the partial sum

$$(8) \qquad b(1) \log w_1 + b(2) \log w_2 + \cdots + b(j) \log w_j,$$

which could serve as an alternative to (6) as a state variable when yield is expressed by (5).

In contrast to a single state variable being sufficient, a general quadratic in $w_1, w_2, \cdots w_M$ would require a state variable for each w_i, $i \leq j$, to summarize the influence of $w_1, w_2, \cdots w_j$ on yield. Thus, at the beginning of period $j+1$ the quadratic would force us to use j state variables to measure crop condition, while the Cobb-Douglas would require only one state variable.

A functional form that has proved versatile and effective in explaining crop yields for the authors is the following general class of functions:

$$(9) \qquad \psi(Y) = h\left(\sum_{i=1}^{M} \phi_i(W_i) \right),$$

where Y is crop yield and W_i is a vector of climatic and cultural variables (including irrigation) to which the crop was subjected during period i. The function ψ is a monotonic transformation of yield, while h and ϕ_i are completely arbitrary functions. Most of the authors' work has been with untransformed yield and h and ϕ_i polynomials, although small grain yields have been successfully analyzed with exponential and logarithmic forms of h and ϕ_i.

An equation used by Doll [9, p. 82] is a special case of (9), where h is quadratic and ϕ_i is linear. The Cobb-Douglas also falls in this class of functions, as can be seen by comparing (7) with (9). The "constant elasticity of substitution" production function, which is currently popular in analyzing aggregate economic data, is also included under (9).

Equation (9) requires only a single state variable and has the virtue of relatively few parameters in most cases. The state variable is the partial sum $\phi_1(W_1) + \phi_2(W_2) + \cdots + \phi_j(W_j)$. With this background on the role of production functions in defining state variables, we are ready to formulate the dynamic programming model for irrigation.

The dynamic programming model

The assumptions of negligible additions to storage during the irrigation season and a zero value to water in storage at the end of the irrigation season permit a per acre formulation that greatly simplifies the investment decision. Storage capacity, water applied, etc., are specified on a per-acre basis.

The following formulation uses only precipitation as a climatic variable in the production function, but the application given later in the paper includes temperature and precipitation jointly. The objective here is to present the logic of the method without cluttering the exposition.

The usual convention of dynamic programming will be used in which stages are counted from the end of the planning horizon instead of the beginning. The relationship between stages of the decision process and time periods is portrayed in Figure 1. Note that stage M is first period in the irrigation season, stage 1 is the last period in which irrigation water might be applied, and stage 0 is the harvest or gross valuation period.

The following notation and definitions are

time	1	2	· · ·	M−1	M	M+1	
stage	M	M−1	· · ·	2	1	0	

Figure 1. Chronological time contrasted with stages of the decision process

made. The stage of the process is denoted by superscripts, with the index n implying a particular stage, $n=0, 1, \cdots M$. Water is measured in inches per acre.

- s_1^n = a partial sum of terms from the production function which measures "crop condition";
- s_2^n = water in storage;
- u^n = net irrigation water applied (the decision variable);
- v^n = precipitation;
- $G(u^n)$ = gross amount of water that must be withdrawn from storage or pumped;
- $c(u^n)$ = expected costs associated with the decision to apply u^n units of water;
- D = distribution or pumping capacity (per acre);
- $f^n(s_1^n, s_2^n)$ = expected net returns from an n-stage process under an optimal policy when the initial state is that defined by s_1^n and s_2^n (the criterion is maximum expected value of net returns), $n=1, 2, \cdots M$;
- $f^0(s_1^0, s_2^0) = R(s_1^0)$, the net harvest value of the crop.

The formulation is made with the production function of (9), and the climatic vector W is assumed to have only a single component which is the sum of precipitation and net irrigation water denoted by w. The variables are redefined by stages, so that (9) is rewritten

$$\psi(Y) = h(\phi^M(w^M) + \phi^{M-1}(w^{M-1}) + \cdots + \phi^1(w^1)), \tag{10}$$

where $w^n = u^n + v^n$.

The state variable transformation functions are

$$\begin{aligned} s_1^M &= 0 \\ s_1^{n-1} &= s_1^n + \phi^n(u^n + v^n), \\ &\qquad n = M, M-1, \cdots, 2, \\ s_1^0 &= h(s_1^1 + \phi^1(u^1 + v^1)) = \psi(Y), \end{aligned} \tag{11}$$

$$\begin{aligned} s_2^{n-1} &= s_2^n - G(u^n), \\ G(u^n) &\leq s_2^n, \quad n = M, M-1, \cdots, 1. \end{aligned} \tag{12}$$

Equations (11) should be clear from the production function (10). Starting at $n=M$ and iterating, we see that

$$s_1^{n-1} = \phi^M(u^M + v^M) + \cdots + \phi^n(u^n + v^n), \quad n = M, M-1, \cdots, 2,$$

which is merely a partial sum of the terms in the production function. Transition to the last stage finishes the sum and ties the additive components together with the function h. The terminal value function $R(s_1^0)$ then assigns a net harvested value to the transformed yield $\psi(Y)$.

The last transformation, equation (12), is obvious since water in storage next period is what there was this period minus withdrawal this period, which cannot be more than was in storage. Recall the assumption of no additions during the irrigation season. Initial storage at the beginning of the irrigation season, s_2^M, will be some known number.

Sufficient basis has now been laid to make the dynamic programming formulation complete with the recurrence equation:

$$\begin{aligned} f^1(s_1, s_2) &= \operatorname*{Max}_u \left[-c(u) + Ef^0(h(s_1 + \phi^1(u + v^1)))\right] \\ f^n(s_1, s_2) &= \operatorname*{Max}_u \left[-c(u) + Ef^{n-1} \cdot (s_1 + \phi^n(u + v^n), s_2 - G(u))\right], \\ &\qquad n = 2, 3, \cdots, M, \end{aligned} \tag{13}$$

subject to the constraints

$$G(u) \leq s_2$$
$$u \leq D$$

The superscripts denoting stage have been deleted from s_1, s_2, and u to simplify the equations, but each is implicitly the variable associated with stage n. The expectation operator is denoted by E.

Solution methods for (13) are given in [3]. Basically, the procedure is to solve for the entire equation $f^1(s_1, s_2)$ by numerical methods, then solve for $f^2(s_1, s_2)$, and so on until $f^M(s_1, s_2)$ is obtained. A unique feature of dynamic programming is that solutions are obtained for the entire state variable space, i.e. all pairs of values for s_1 and s_2. This is of no consequence for s_1, which always begins stage M (first period of the irrigation season) at the same

level, namely zero. But the second state variable is water in storage, and for a given size reservoir the probability distribution for initial storage could be computed.

An Integration of the Investment and Temporal Allocation Models

Let us define a new function:

$$(14)\quad g(s_2, D) = f^M(0, s_2), \qquad \text{for given } D.$$

Equation (14) is expected net returns per acre under an optimal irrigation policy for an initial amount of water in storage per acre of s_2 and distribution capacity of D units of water per acre.

Going back to the investment decision model, total storage is x, distribution capacity is y (not to be confused with crop yield), and number of acres developed is z. First, we note that acres considered for irrigation in a given year need not be z but can be something less, say $A \leq z$. Denote total water in storage at the beginning of the season as S; then $s_2 = S/A$ for a given year. Total expected returns for the year, given S, A, and y, are $g(S/A, y/A)A$ since $D = y/A$. We can thus make a conditional optimization,

$$(14\text{a})\quad \max_{A \leq z} g(S/A, y/A)A = g^*(S, y, z),$$

for any given value of S.

But S is a random variable that contains x as a parameter in its probability density function. Taking the expected value of $g^*(S, y, z)$ with respect to S for given x, we get a function

$$(14\text{b})\quad \bar{g}(x, y, z) = Eg^*(S, y, z).$$

After adjusting $\bar{g}(x, y, z)$ for replacement and maintenance costs of the investment components in irrigation, we obtain the quasi-rent functions $N_t(x, y, z)$. This completes the methodological part of the study, and an application to corn irrigation in Missouri follows.

Application to Corn Irrigation in Central Missouri

The mathematical model just formulated was used to analyze the economics of corn irrigation in central Missouri, primarily to provide results that could be applied to evaluate investments in irrigation at the farm level. Since the model is structured on a per acre basis, its results are applicable to diverse farm situations. Hence, experiment station research conducted with the per-acre model can be utilized with a minimum of specialized analysis at a given farm site.

The production function for corn

Space does not permit a detailed discussion of the problems associated with estimation of a yield response surface for corn when climatic variables are included as explanatory variables. The task is complicated by the many variables involved and their apparent nonlinear influence on yield. Technically, the magnitude of each daily climatic factor is a separate explanatory variable, but many simplifications are necessary to make statistical estimation feasible. A minimum number of climatic factors must be included in the response function since precipitation in subhumid areas provides part of the crop-available-moisture, and precipitation is correlated with other climatic factors—temperature in particular.

Water (precipitation plus irrigation water) and temperature during the development periods of the corn crop were selected as the most crucial factors affecting yield. Preliminary statistical analysis, guided by previous research [5, 8, 12, 14, 16, 18, 19], indicated that the three 10-day periods prior to tasselling, the 10-day period including tasseling, and the two 10-day periods following tasseling were the periods showing the highest correlation between corn yield and water and temperature.

Elaborate methods of measuring moisture stress of corn have been developed [7, 21]. However, in this study simple transformations of water and temperature data were the explanatory variables used in the equation to estimate the yield response surface. Sufficient data to justify more sophisticated moisture stress measures were not available.

The production function to be used in the irrigation decision model contains other than climatic factors which are fixed at specified levels. These other factors, such as fertilizers and plant population, determine a separate production function in the climatic variables for each set of values that are specified for them. If one were to irrigate with a plentiful water supply, these auxiliary factors should be relatively high; conversely, as the irrigation water supply approaches zero, they should be at the optimum for dryland conditions. This study was conducted with the ancillary factors at a single set of values, since experimental data were not available for multiple levels.

The set of data used left much to be desired,

particularly with respect to the range of variation on water received. Only 122 observations were available and they were from unreplicated plots. Plant populations were 15,000 per acre and nitrogen application was 175 pounds per acre. A serious deficiency of the data was the absence of a record of occurrence of phenological events: emergence, tasseling, silking, and physiological maturity.

The following notation is used, with t denoting a particular 10-day period in the irrigation season:

v_t = precipitation;
u_t = irrigation water applied;
w_t = sum of irrigation water and precipitation truncated from below at .35 inch;
T_t = sum of daily maximum temperatures;
T_t^* = sum of the portion of daily maximum temperatures *exceeding* 85°F for all periods except $t=4$, and 90° for $t=4$;
T_t^{**} = sum of the portion of daily maximum temperatures *below* 85° and 90° for $t\neq 4$ and $t=4$, respectively;
$I_t = T_t^*\sqrt{\text{Max}(0,\ \omega_t - .35)}$ an interaction variable between water and high temperatures;
$t = 1, 2, \cdots 6.$

The purpose of truncating w_t was to discount the importance of extremely small amounts of precipitation during a given period. Temperature was divided into an upper and lower range in order to capture the obvious nonlinearity of its effects. Limited variation in the observed temperature values and the consequent high correlation between T_t and T_t^2 prohibited estimation of curvilinear effects through the use of a quadratic term in the model. Preliminary statistical analysis resulted in a better fit and more reasonable interpretation of temperature effects if the division of temperature was made at 90°F for the tasseling period and 85°F for all other periods.

The square root transformation of the water factor in the interaction term allowed diminishing returns to water within the interaction term and gave a better fit to the data. Effect here refers to the partial effect within a given 10-day period of a change in the water variable.

The equation fitted to corn yield is a form of (9) with linear terms added:

$$y = B_0 + B_1 U + B_2 U^2 + \sum_{t\neq 4} C_t T_t + C_4 T_4^* + C_4' T_4^{**} \tag{15}$$

where

$$U = \sum_{t=1}^{6} (a_t w_t + b_t w_t^2 + c_t I_t).^2 \tag{16}$$

A simplification of the above equation which deleted the first and last periods made only a trivial difference in the explanation of sample corn yields. Therefore, the model was simplified to include only four periods, i.e., periods for $t=2, 3, 4$, and 5 in equations (15) and (16). The estimated coefficients and other statistics of interest for the final model are presented in Table 1.

Table 1. Regression coefficients and other specified statistics for the estimated model

Coefficient	Associated variable	Estimate	Standard error
A. Weights or variables included in the composite variable			
a_2	w_2	7.9906	3.633
a_3	w_3	16.6982	3.138
a_4	w_4	− 4.3966	5.737
a_5	w_5	5.0473	7.368
b_2	w_2^2	− 0.0949	1.023
b_3	w_3^2	− 0.7414	0.450
b_4	w_4^2	0.8709	1.305
b_5	w_5^2	0.0757	0.248
c_2	I_2	− 0.1185	0.101
c_3	I_3	− 0.5991	0.046
c_4	I_4	1.2816	0.135
c_5	I_5	0.1384	0.067
B. Coefficients of the general polynomial			
B_0	—	−136.8968	—
B_1	U	170.6940	10.384
B_2	U^2	− 90.6738	8.933
C_2	T_2	.1449	0.037
C_3	T_3	.3458	.052
C_4'	T_4^{**}	.3674	.086
C_4	T_4^*	− 1.7531	0.101
C_5	T_5	− .5636	0.040

Standard error of the estimate: 9.40.
Coefficient of determination: 0.887.

Relatively satisfactory statistical reliability was obtained for parameter estimates in equation (15) (Table 1, part B), but the standard errors are quite large on parameter estimates of equation (16) (Table 1, part A). We did not resort to picking off separate parameters that were not significant at some arbitrary level but examined comprehensive changes in the algebraic form across all periods. The quadratic

[2] The set of parameters, $\{a_t, b_t, c_t\}$, are unique only up to a scalar multiple. Most statistical estimation procedures would require imposition of a constraint, such as the parameters summing to unity. However, the particular nonlinear least squares algorithm used by the authors was "custom built" for equations (15) and (16) and did not require such a constraint.

effects obtained by inclusion of b_2, b_3, b_4, and b_5 are justified only marginally on a statistical basis, but we chose to include them.

Estimation of a weather-yield response surface makes it possible to proceed with the task of determining optimal irrigation policies for corn. The final version of the yield response surface contains only four 10-day periods—the two periods prior to tasseling, the tasseling period, and the period after tasseling. Therefore, the intraseasonal decision process consists of five periods—the above four production periods plus a terminal or market period. The terminal period is an instantaneous end of the process rather than a time interval.

The empirical problem thus reduces to the model summarized by equation (13), $n=0, 1, \cdots 4$. Since the terms of equation (15) that explicitly involve temperature are additive, their expected values can be added to the constant term for purposes of the temporal allocation problem; therefore (15) reduces to

$$y = B_0' + B_1 U + B_2 U^2 \tag{17}$$

where

$$B_0' = B_0 + \sum_{t \neq 4} C_t E(T_t) + C_4 E(T_4^*) + C_4' E(T_4^{**}).$$

Since the first and sixth (last) periods have been deleted from the production function, U contains only four terms in the summation in (16) and the above summation of expected temperatures also deletes $t=1$ and $t=6$.

The general function of (9) for this special case is defined with

$$\begin{aligned} \phi_i(W_i) &= a_i w_i + b_i w_i^2 + c_i I_i \\ &= a_i(u_i + v_i) + b_i(u_i + v_i)^2 \\ &\quad + c_i T_i^* \sqrt{\operatorname{Max}(0, u_i + v_i - 0.35)} \end{aligned} \tag{18}$$

$$h(U) = B_0' + B_1 U + B_2 U^2, \tag{19}$$

and the function $\psi(Y)$ is suppressed. The vector of climatic variables in (9) is comprised of the three components u_i, v_i, and T_i^*.

We now define the periods of the irrigation season with respect to stages remaining in the decision process (see Figure 1); and (18) for stage n is defined as

$$Z^n = a_n w_n + b_n w_n^2 + c_n I_n, \quad n = 1, 2, 3, 4. \tag{20}$$

The recursion formula of (13) for this application is

$$\begin{aligned} f^1(s_1, s_2) &= \operatorname*{Max}_u \left[-c(u) + ER(B_0' + B_1(s_1 + Z^1) + B_2(s_1 + Z^1)^2)\right], \\ f^n(s_1, s_2) &= \operatorname*{Max}_u \left[-c(u) + Ef^{n-1}(s_1 + Z^n, s_2 - G(u))\right], \\ &\qquad n = 2, 3, 4. \end{aligned} \tag{21}$$

The maximization operation is subject to the constraints given in (13). The stochastic nature of the problem stems from the random variable Z^n which is a function of precipitation, temperature, and irrigation water applied in stage n. Recall that the function $R(\psi(Y)) = R(Y)$ in this application is gross value of the crop minus harvest costs.

There is great practical advantage in reducing the number of state variables in (21) to only one in order to obtain a numerical solution to the equations and an approximately optimal policy. In nonstochastic problems, a state variable can be eliminated by introduction of a Lagrange multiplier to represent an internal price for a resource [3, p. 52] such as stored water in this application. The transformation function associated with stored water, s_2, is nonstochastic, but the total model is stochastic. In this situation the Lagrange multiplier method of eliminating a state variable yields an approximately optimal policy, which should be quite close to optimal if properly interpreted.

Numerical solution also requires the remaining state variable, s_1, and the decision variable, u, to be approximated by discrete intervals on their continuous scales of measurement. These intervals on s_1 and u are denoted by $i=1, 2, \cdots M(n)$ and $k=1, 2, \cdots K$, respectively. The probability distribution for s_1+Z^n can be summarized by the finite set of probabilities:

$p_{ij}^k(n)$ = the probability that the process will occupy the jth state in stage $(n-1)$, given that it occupies the ith state in stage n and that the kth decision is made. The parenthetical n denotes that the probability of moving from one discrete level of the state variable to another changes from stage to stage.

With these modifications, the recurrence relation (21) can be approximated by

$$f^n(i) = \underset{k}{\mathrm{Max}}\left[-c(u_k) - \lambda G(u_k) + \sum_{j=1}^{M(n-1)} p_{ij}^k(n) f^{n-1}(j)\right] \tag{22}$$

where λ is the Lagrange multiplier, $M(n)$ is the number of states associated with the nth stage, and $f^0(j) = R(Y)$. The relation $f^n(i)$ corresponds to the earlier definition of $f^n(s_1, s_2)$ with i implying the ith discrete level of s_1 and the second state variable s_2 suppressed. The summation in the above expression corresponds to the expected value of $f^{n-1}(s_1+Z^n, s_2-G(u))$ in (21), but the second argument in f^n has been deleted by using the Lagrange multiplier on $G(u)$. The level of λ rations stored water, which eliminates the constraint $G(u) \leq s_2$.

Numerical solution of (22) is accomplished by computing the sequence $f^0(i)$, $f^1(i)$, $\cdots f^4(i)$, $i=1, 2, \cdots M(n)$; but of course, an electronic computer is required for a problem of much size. Many separate solutions are required for a range of values on λ, i.e., the recurrence relation in (22) could be more descriptively written as $f^n(i|\lambda)$. This procedure yields a series of solutions that are increasingly conserving of water as λ increases. That is, for each specified value of λ, there exists a corresponding policy and expected quantity of water used (available stock) under that policy. The one-to-one correspondence between policies associated with λ and expected quantities of water used (available stock) yields the answer to the question of how a limited stock of water should be allocated. The computational procedures of dynamic programming yield answers to this question at all stages and for all states of the sequential decision process.

The results obtained in solution of the problem introduce additional flexibility into selection of an approximately optimal policy which was not included in the original formulation of the problem. Results are available that make it possible to modify the derived policy at each stage as additional information becomes available. To illustrate, assume that a given quantity of water is available at the beginning of the decision process. The decision maker should select the derived policy for that stage as indicated by the value of λ which most nearly exhausts the quantity of water available (for the entire season in an expected value measure). Following this policy the decision maker will find his crop in some specified state one stage later when he again is confronted with selection of a policy that will maximize expected return. The stock of water available for allocation, as well as crop condition, may now be different from that anticipated, based on information available in the previous period. This difference could arise from rainfall resulting in runoff, equipment failures, sufficient precipitation to reduce the need for irrigation, or other factors such as unusual temperatures. The decision maker owes no allegiance to continuation of the policy indicated by the appropriate value of λ in the nth stage; he should follow a policy in the $(n-1)$ stage that will just exhaust (in an expected value sense) the stock of water presently available. Again, this selected policy will be associated with the value of λ which just exhausts the water in storage, given the state variable describing crop condition. The computational procedure yields results that allow for the selection of an approximately optimal policy stage by stage as new information becomes available.

The method of Lagrange multipliers applied to this problem yields policies that deviate from optimal insofar as the stochastic part of the process gives rise to changing marginal values of stored water among stages of the process. In a deterministic process marginal values would be equated among stages; but in a stochastic situation, only expected marginal values would be equal under an optimal policy. However, errors are greatly reduced by the above flexible interpretation of the decision rule. For a single-stage process, the method is optimal; for a two-stage process, error stems only from the random transition between the two stages, etc. The relatively short process involved in this application reduces the errors, and the generalized interpretation of the decision rules prevents compounding of the errors from stage to stage.

Empirical measures used

Transition probabilities $\{p_{ij}^k(n)\}$ were derived from a 74-year series of precipitation and temperature data collected at Columbia, Missouri, about 30 miles from the experimental site of the data. Since Z^n is implicitly a function of w_n and I_n which are in turn implicitly functions of u_k, it is more explicit to write Z_k^n for the discrete variable decision model. The probability distributions of Z_k^n were estimated by relative frequencies from the 74-year weather series. Since $k=1, 2, \cdots 5$ and $n=1, 2, 3, 4,$

twenty separate probability distributions were required. The five levels of net irrigation water application were 0, 1.6, 1.9, 2.2, and 2.5 inches for $k=1, 2, 3, 4, 5$, respectively. The number of discrete states in each stage, $M(n)$, are 48, 42, 23, 8, and 1 for $n=0, 1, 2, 3$, and 4, respectively.

One complication was encountered in computation of the transition probabilities. The 10-day periods are not fixed calendar periods but are related to the critical growth stage for corn, where tasseling date is taken as a base. This implies that the tasseling date of corn must be known for each year in the weather series before the probability distributions of the Z_k^n variables can be derived. Tasseling date was estimated for each year in the series using the method outlined by Stauber, Decker, and Zuber [20].

Items included in variable costs were fuel, oil, repairs, and labor. The computed costs per acre and related data are presented in Table 2 for selected rates (u_k). The variable costs per acre exhibit increasing costs per unit of water because of the decreasing soil infiltration rate of water per unit of time.

The function $R(Y)$, which defines gross returns from Y units of the crop per acre with harvest costs deducted, is simplified to \$.91Y, where 91 cents is the net price of corn per bushel and Y is in bushels. Production costs are assumed constant except for variable costs of water application and costs of harvest. The simplified relation $R(Y)=\$.91Y$ implies a cost of harvest proportional to yield which is merely a convenient approximation.

Empirical Results

Solution of the discrete model for the case where $\lambda=0$ is presented in Table 3. Solutions for other values of λ are similar but must be omitted because of space limitations. The case of $\lambda=0$ implies stored water is not an effective constraint at any point in the season. The optimal decision, expected returns per acre, and expected water use per acre are presented for all relevant stages and states. Expected returns per acre refer to the net market value of the crop minus variable irrigation costs. The greater λ (internal price of water), the more conserving of water is the optimal policy and the lower the expected returns per acre. Of course, the internal pricing of water through λ is not reflected in the expected returns measure presented.

The general pattern of optimal policies for λ greater than zero is much the same as that in Table 3. At higher values, progressively smaller

Table 2. Variable costs of applying specified amounts of supplemental irrigation water to corn

Gross application per acre $G(u_k)$	Net application per acre (u_k)	Duration of application	Variable cost per acre $c(u)$	Variable cost per acre inch (net)
inches	*inches*	*hours*	*dollars*	*dollars*
1.90	1.60	4.0	2.71	1.69
2.40	1.90	5.2	3.25	1.71
2.94	2.20	6.6	3.89	1.77
3.55	2.50	8.2	4.61	1.84

Table 3. Unconstrained water availability, lambda equal to zero: optimal decision, expected returns per acre, and expected water use per acre, by stage and state for corn

Value of the state variable	Optimal decision (net inches of water applied)	Expected returns[a] (dollars)	Expected water use (gross inches of water applied)
	$n=4$		
0	2.50	115.49	6.93
	$n=3$		
− .20	0	97.37	5.70
− .10	0	104.64	5.10
0	0	110.97	4.52
.10	0	116.39	3.86
.20	0	121.16	3.31
.30	0	125.16	2.75
.40	0	128.31	2.30
.50	0	130.40	1.76
	$n=2$		
−1.20	2.50	20.93	4.90
−1.10	2.50	25.70	5.15
−1.00	2.50	31.19	5.39
− .90	2.50	37.67	5.77
− .80	2.50	45.50	6.25
− .70	2.50	54.93	6.62
− .60	2.50	65.59	6.73
− .50	2.50	76.45	6.61
− .40	2.50	86.48	6.50
− .30	2.50	95.15	6.38
− .20	1.90	102.72	5.21
− .10	1.60	109.54	4.68
0	1.60	115.08	4.46
.10	0	119.62	3.16
.20	0	124.67	2.95
.30	0	128.36	2.60
.40	0	130.84	2.12
.50	0	132.28	1.44
.60	0	132.80	.66
.70	0	132.46	.07
.80	0	130.92	0
.90	0	127.79	0
1.00	0	123.01	0

Table 3. Continued

Value of the state variable	Optimal decision (net inches of water applied)	Expected returns[a] (dollars)	Expected water use (gross inches of water applied)
	$n=1$		
−1.30	0	0	0
.	.	.	.
.	.	.	.
− .80	0	0	0
− .70	2.50	2.57	3.55
− .60	2.50	14.24	3.55
− .50	2.50	30.50	3.55
− .40	2.50	47.76	3.55
− .30	2.50	63.54	3.55
− .20	2.50	77.67	3.55
− .10	2.50	90.14	3.55
0	2.50	100.97	3.55
.10	2.50	110.15	3.55
.20	2.50	117.67	3.55
.30	2.50	123.55	3.55
.40	2.50	127.78	3.55
.50	2.20	130.75	2.94
.60	1.60	132.66	1.90
.70	0	134.43	0
.80	0	135.94	0
.90	0	135.80	0
1.00	0	134.00	0
1.10	0	130.56	0
1.20	0	125.46	0
1.30	0	118.71	0
1.40	0	110.32	0
1.50	0	100.28	0
1.60	0	88.58	0
1.70	0	75.38	0
1.80	0	60.24	0
1.90	0	44.02	0
2.00	0	26.98	0
2.10	0	11.16	0
2.20	0	1.98	0
2.30	0	0	0
.	.	.	.
.	.	.	.
2.80	0	0	0

[a] Net returns are equal to net market value of the corn crop minus variable irrigation costs. Corn valued at a net market price of 91 cents per bushel.

and smaller applications of water are made at a given stage and state; also applications are made at fewer states. Interpretation of the optimal policy for any value of λ is straightforward. At each stage and for any state defined for that stage, the appropriate decision, expected return, and expected amount of water needed to implement the optimal policy through the present and subsequent stages of the season are presented.

The results define optimal policies for all stages and states under all meaningful levels of water availability. The results for stage four are particularly interesting as they provide information that is useful in an organizational as well as an operational sense. The expected returns for stage four comprise the annual expected net market value of the crop minus variable irrigation costs. Deduction of other production costs and appropriate overhead costs would allow evaluation of the profitability of irrigated corn production.

One surprising result is that no irrigation water is ever applied during stage three, the period before tasseling. An apparent explanation is the discrete nature of the irrigation variable combined with a production function that makes overirrigation a possibility. The quadratic function in the composite variable U definitely permits negative effects from too much water. Sequencing of the discrete levels of irrigation permitted, and the stochastic environment, could easily give a decision rule that delayed irrigation from the third stage to the second. Also, the heavy irrigation in stage four may partially substitute for irrigation in stage three.

Variability of returns as an additional criterion

Variance of returns is an important economic consideration in making the decision to adopt a production or management practice. It seems logical that some control over a random production input such as water would result in reduced variability of returns as well as greater expected returns. The properties of Markov chain transition probability matrices can be exploited to determine the variability of returns for a specified policy. It is possible to find the probability that the process occupies each of its states after moving through a number of stages by post-multiplying the initial-state probability vector by the product of the appropriate transition matrices [15, p. 218]. Specifically, for the model used in this study, let

$P_n =$ the transition probability matrix for stage n under an optimal policy;
$n = 1, 2, 3, 4.$

A specified policy designates a decision, k, to be associated with a given state, i, and stage, n, thereby defining a unique transition matrix for each stage. The elements of the matrix P_n are a subset of the $\{P_{ij}^k(n)\}$.

A terminal-state probability vector, say π, can be computed by evaluation of the following expression:

$$\underset{(1\times 48)}{\pi} = \underset{(1\times 8)}{P_4} \cdot \underset{(8\times 23)}{P_3} \cdot \underset{(23\times 42)}{P_2} \cdot \underset{(42\times 48)}{P_1}$$

Terminal-state probability vectors for an

optimal policy under unconstrained water availability and for dryland conditions are presented in Table 4 to illustrate the nature of the distributions.

The terminal-state probability vectors along with the associated values of gross returns for each terminal-state constitute the probability distribution of gross returns and allow the computation of the expected value of gross returns and variance of gross returns for each optimal policy. Variance of gross returns is a very close approximation to the variance of net returns. They would be identical if production and water costs were the same for all states.

The terminal-state probability vectors and associated values of gross returns were used to compute expected value and variance of gross returns for selected values of λ. The data are presented in Table 5 and indicate a clear superiority with respect to variance of returns for the policies involving intensive water use. The variability of returns (measured by the standard deviation) for the "unconstrained water availability" case is approximately one-half that of the dryland situation pointing out the twofold benefits provided by irrigation.

Table 4. Value of the state variable, associated corn yield, and probability of occurrence under an optimal policy with unconstrained water availability and for dryland conditions

Value of the state variable[a]	Yield per acre	Probability of occurrence: Unconstrained water availability	Probability of occurrence: Dryland
	bushels		
− .35 or less	0	.0001	.0054
− .30	10.6	.0003	.0108
− .20	32.3	.0009	.0303
− .10	52.1	.0026	.0663
.00	70.0	.0066	.1097
.10	86.2	.0151	.1406
.20	100.5	.0300	.1467
.30	113.1	.0566	.1323
.40	123.8	.0917	.1085
.50	132.7	.1226	.0829
.60	139.8	.1334	.0604
.70	145.1	.1594	.0424
.80	148.5	.1660	.0282
.90	150.2	.1060	.0173
1.00	150.0	.0467	.0097
1.10	148.1	.0262	.0049
1.20	144.3	.0131	.0022
1.30	138.7	.0085	.0009
1.40	131.3	.0062	.0003
1.50	122.1	.0045	.0001
1.60	111.0	.0024	0
1.70	98.2	.0008	0
1.80	83.5	.0002	0
1.90	67.0	.0001	0
2.00	48.7	0	0
2.10	28.6	0	0
2.20	6.7	0	0
2.25 or more	0	0	0
Expected yield (bushels)		136.9	102.5

[a] Midpoint value of the interval.

Table 5. Variability of gross returns for irrigated corn under optimal policies for specified values of lambda[b]

Lambda	Expected yield per acre	Expected gross returns per acre	Standard deviation	Coefficient of variation
	bushels	*dollars*	*dollars*	
0.0	136.0	124.57	15.23	.122
1.0	134.7	122.57	15.83	.129
2.0	128.3	116.75	18.48	.158
3.0	126.9	115.47	18.15	.157
4.0	123.0	111.93	18.19	.162
5.0	120.4	109.56	18.32	.167
6.0	115.8	105.37	19.31	.183
8.0	111.2	101.19	21.73	.214
10.0	105.1	95.24	26.05	.272
Dryland	102.5	93.24	29.67	.318

[a] Gross returns are equal to the net market value of the corn crop valued at a net market price of 91 cents per bushel.

Actually, the data in Table 5 overstate the benefits of intensive levels of water use. These data provide the basis for an analysis using the joint criteria of mean and variance of returns, but the expected gross returns values would need to be adjusted by subtracting amortized fixed costs of investments to provide and apply irrigation water. The joint-criteria decision models tacitly assume a sacrifice in one criterion to gain in the other, at least within the relevant region for decision making [4, 11, 17]. This would require a direct relationship between the mean and variance of returns in the relevant decision space. The unadjusted data reflect an inverse relationship between mean and variance of returns.

Adjustment of expected gross returns by subtraction of amortized fixed investment costs for each value of λ would probably result in an expected return function that is unimodal in the variable λ and reaches its maximum where $\lambda > 0$. This maximum would result from the rapidly increasing levels of investment necessary in most farm situations to achieve the intensive levels of water-use reflected by small

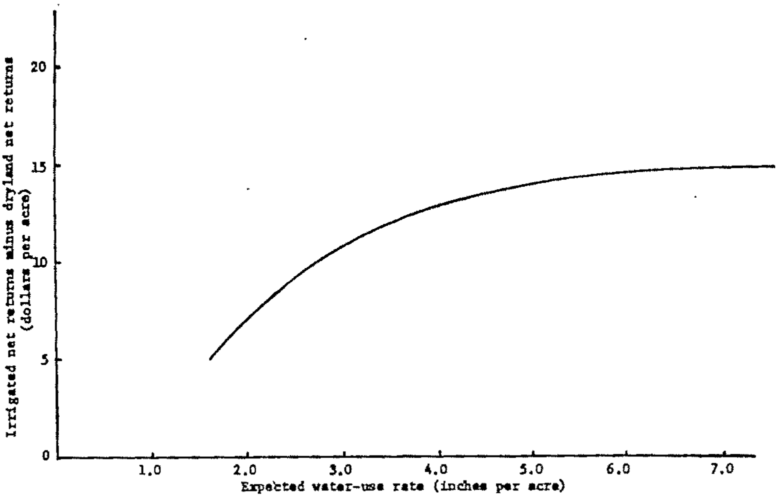

Figure 2. Relationship between water-use rates and the per acre differential in irrigated net returns and dryland net returns.

lambda values. If this were the case, the decision maker would be confronted with the choice of how much expected income to sacrifice for reduced variability in income, or vice versa.

Application of results to the investment decision

The temporal allocation model used water in storage per irrigable acre as a state variable, which tacitly requires all acres to receive the same irrigation treatment. The investment decision framework presented at the beginning of the paper is now applied to this simplified situation. This application further assumes that there is an ancillary relation dictated largely by engineering considerations that specifies y as a function of x and z for any on-farm situation. Therefore, the quasi-rent function is reduced to simply $N_t(x, z)$ for a given farm situation.

The initial cost of investment function, $I(x, y, z)$, is also simplified by the above assumption about distribution capacity and is redefined without the argument y as $I(x, z)$. This function is viewed as that associated with a particular farm situation with given physical conditions for building storage reservoirs and developing irrigable land. Replacement and maintenance costs that are implied by an initial investment of $I(x, z)$ are reflected in the future quasi-rents, $N_t(x, z)$.

We need the counterpart of $\bar{g}(x, y, z)$, given by equation (14b), with the argument y suppressed; we denote that function by $\bar{g}(x, z)$. Likewise, the second argument of $g(s_2, D)$ in equation (14) is suppressed, giving the simplified function $g(s_2)$. Recall that s_2 is water in storage per acre at the beginning of the season and $g(s_2)$ is expected net returns per acre following an optimal irrigation policy. The approximating device of the Lagrange multiplier used in the application yields a function comparable to $g(s_2)$ except that the argument is expected water used per acre irrigated under an optimal policy. This latter function is used to approximate $g(s_2)$, and equations (14a) and (14b) provide the means for obtaining $\bar{g}(x, z)$. The function used to approximate $g(s_2)$ is graphed in Figure 2. The graph has been scaled as a differential above dryland expected returns, which merely forces $g(s_2)$ through the origin instead of it having a positive intercept.

Any analysis from this point would be specific to some farm irrigation site, and the function $\bar{g}(x, y)$ would have to be estimated for the particular farm for which investment in irrigation is being considered.

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The Team Approach and Extension Economics

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With the introduction of new Extension programs in such nontraditional areas as recreation, community resource development, environmental quality, etc., Extension economists will experience some loss of professional autonomy. Rarely will the resources required by these programs be found within the agricultural economics profession alone. This paper proposes that Extension economists adapt the team approach to their contemporary programs. More specifically, the Program Mission Organization is suggested as the interdisciplinary form of organization most applicable. The benefits and limitations of the team approach are then examined in light of a need for operational efficiency within and between all Extension economics programs.

IN THE Snake River Canyon of northern Idaho can be found ancient Indian pictographs showing a hunter chasing his game in the direction of his hidden companions to facilitate the kill. These drawings stand as evidence that the team approach to one's pursuits is hardly a new concept. Perhaps the greatest testimonial in favor of the team approach is that it has not only endured over the ages but has permeated so many aspects of our lives. Its relevance to programs in Extension economics is now being illustrated [2, 6].

Extension agricultural economists are rarely blessed with work patterns of predetermined origin. Their efforts are directed towards so-called "real world problems," the solutions to which are rarely found within the agricultural economics profession alone. Extension economists are often not allowed the luxury of selecting and pursuing a specific phase of a broad problem; instead, they must consider the whole problem and assemble that talent (even from outside our profession) needed to achieve an ultimate solution. As a result, the work of Extension economists often appears in the form of a contribution to a team effort. The team, itself, may be interdisciplinary or intradisciplinary in nature. Regardless, within the context of a team approach, the pursuit of an individually preselected subject matter becomes difficult, if not impossible. One no longer functions as an agricultural economist. Instead, his talents are meshed with those of other scientists to form a broad resource base from which talents are drawn according to the need rather than according to personal preferences.

Hence the team approach to the conduct of programs in Extension economics has considerable appeal, and I propose that the team approach should become a dominant feature of Extension programs. If this is to be achieved, however, numerous operational problems inherent in the team concept itself must first be overcome. Furthermore, other problems concomitant with the team approach (e.g., coordination, the natural human desire for professional autonomy, and psuedo-commitment) have not been adequately considered.

In support of my proposal, the objectives of this paper are four-fold: (a) to define the team approach and describe its three alternative conceptualizations; (b) to discuss the adaptability of the team approach to Extension as a formal organization; (c) to elaborate on the benefits and limitations of the team approach as they apply to agricultural economics Extension; and (b) to discuss other operational problems inherent in the administration of Extension economics programs based on the team concept and offer some potential solutions.

Definition

The team approach is commonly defined as a singular all-encompassing phenomenon whereby "two or more persons commit themselves to a series of systematic actions" [2, p. 83]. Students of management have dissected and categorized the team approach into a more definitive and workable multiplicity.

Wickesburg and Cronin [9], in establishing a team concept, called it a Task Force (a term first used in the U. S. Navy), that is a team of persons under singular command, devoted to the accomplishment of a specific objective or mission. Members of a task force are drawn mainly from within the organization and are selected for their potential contribution to the successful attainment of the mission. Once the task has been accomplished, they are returned to their original organizational units. The task force itself therefore enjoys only a temporary existence in the organization's total life span.

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In 1967, Reeves suggested that "if a task force is to be effective it must have considerable autonomy within the area of responsibility assigned to it "[7, p. 75]. The granting of such autonomous authority requires that the organization have such clearly defined areas of responsibility that managerial control is not sacrificed. Unfortunately, as will be discussed later, enucleated bureaucracies such as Extension find it difficult to establish clearly defined procedures and lines of responsibility. The task force form of the team approach therefore is rarely appropriate in Extension.

The team approach is followed by some multifunctional organizations; e.g., construction firms often subcontract several functional activities such as electrical, plumbing, and masonry work. But the task force concept is rarely applicable to this type of multifunctional activity because its application requires the forfeit of many multifunctional attributes. The Matrix Organization concept of the team approach then was developed by William G. Scott [8] who described the organizational and procedural relationships that emerge when an organization applies the team approach across functional lines. Scott's perception of the resultant matrix shows the various teams (each having a nonfunctional orientation) listed on the vertical axis and the organizations's functions listed across the horizontal axis. Cross-representation (i.e., a team member in each function or a functionary on each team) is mandatory. As a result, the matrix organization must be conceptualized as a total system that is constructed to achieve maximum team-function coordination. It proves most practical, therefore, when applied to organizations concerned with a large number of relatively small projects, each requiring a homogeneous mix of functional talents. Rarely is this characteristic of our modern-day Extension activities with their problem, not functional, orientation.

Finally, Johnson, Kast, and Rosenzweig [4] defined a third team concept called the Program Mission Organization (P.M.O.). Under P.M.O. each task assigned to a team was related to a mission. Each mission was dependent on (a) perceiving a need, (b) designing a successful program, (c) stimulating a demand for the program, (d) conducting the program effectively, (e) distributing relevant information, and (f) educating potential program users. This team concept has proven most beneficial to organizations that are composed of a variety of programs ranging in size, scope, complexity, and duration. The six-point mission criterion forms the basis for some degree of uniformity, continuity, and cohesiveness among the program teams.

Of the three concepts of the team approach, P.M.O. seems most consistent with the composition of most Extension economics programs.

Composition

A team must not be confused with a committee; it is granted a different scope of authority and responsibility. For example, a team is rarely created to act as a judiciary body, nor is it primarily an educational or training body. A team is assigned a mission; it has a leader and often a mandatory completion date. Rarely is a team in a position to "pass the buck," postpone a conclusion, or file a minority report. While a committee is normally asked to conduct an investigation and report its findings to a governing body, a team is established to take positive action in response to its findings and is given the authority to do so. The performance of a team, unlike that of a committee, is often rather abrupt; e.g., it either succeeds or fails.

The team, therefore, is an action-oriented group of individuals. Team membership is not based on the fact that the assigned topic may simply "be of interest" to an individual nor that all political factions or academic departments "must have a representative spokesman." Unlike a committee, a team may range from an informal temporary assortment of persons constituted to attack a minor short-lived problem to a highly sophisticated assembly of specialists designed to ponder more dynamic and expansive difficulties. In the former, the team member may maintain his administrative ties and normal responsibilities with his own department or discipline; in the latter, all such ties may be severed for a designated period of time during which full-time efforts are team-directed.

Most authors choose not to describe where, between these two extremes, their envisioned teams would lie. Yet, between these two extremes exists an infinite number of task-related team compositions, each requiring a unique organizational structure. I shall mention only four possibilities:

(1) Team members remain in their functional or departmental location and area of supervision, but work related to the team effort takes priority over functional or departmental work.

(2) Team members remain in their functional or departmental location but are officially assigned to the team leader for work scheduling and related administrative purposes.
(3) Team members are located temporarily away from their normal employment location and are grouped with other team members in an area specifically assigned to their program.
(4) Team members are located physically outside the delegating agency and under the authority of the team leader for the duration of the program.

Extension economists are familiar with these and other location-function-administrative combinations; e.g., their activities are often supervised by some combination of administrators from both Extension and the academic department.

Adaptability

According to Becker and Gordon's taxonomy of formal organizations [1], Extension could be described as an enucleated bureaucracy [1, p. 329], i.e., an organization in which the administrator (institution) stores the specific resources (scientists) necessary for goal achievement (problem solution) but finds it difficult to specify the procedures for their coordination because of complex environmental interaction and the need for rapid response to problems [1, pp. 324 and 333]. These authors define a "specific resource" as one stored by the organization in the form necessary to implement a program with the administrator's intent that it be used; and "procedures specified" as administrative requirements that a volitional resource perform a planned activity in the attainment of the goal [1, pp. 322–323].

Under such an organization, the employees generally specify their own work procedures, and self-coordination soon replaces the need for large amounts of direct administrative control. This is the type of academic freedom enjoyed and preferred by most Extension economists. It results in uses of resources as sanctioned through consensus among Extension economists rather than by administrative directive. An enucleated bureaucracy's authority pattern appears as a system of control in which some authority is shared by all members of the working group (team). Not only does this classification typlify Extension; it also describes a campus organization particularly well suited to the adoption of the team approach, i.e., both the organization and the approach imply an administrative pattern whereby ".... much authority is deemed to rest in groups of people (teams) rather than in an individual (an administrator)" [5].

The team approach, therefore, is easily adopted by an enucleated bureaucracy such as Extension. In fact, when it is adopted, the resultant organization is described by Becker and Gordon as an internally coupled enucleated bureaucracy [1, p. 325].

Benefits

Mankind has long been aware of the many favorable attributes of the team approach. The following benefits are most often acknowledged:
(1) By virtue of its multispecialist composition, a team is better able to cross organizational lines and shortcut time-consuming conventions in an attempt to move rapidly on a problem.
(2) Diverse professional skills and experience are assembled to facilitate the solution of problems requiring expertise beyond a single discipline or academic department.
(3) By encouraging participation of specialists from many functional groups, the team approach discourages empire-building by dominant individuals, departments, or agencies.

Other equally well-recognized benefits of the team approach could be listed. Two of these are directly attributable to Extension economics programs and deserve special mention.

First, the team approach better equips an organization to cope with a rapidly growing need for interpersonal communication. Extension economics programs are characterized by large numbers of different communicating factions, e.g., Extension (including county, area, and state level personnel), the department of agricultural economics, other academic departments, numerous public agencies, and, of course, the audience (which may include farmers, merchants, bankers, etc). The magnitude of this growing communication problem is cause for concern.

Second, Extension economics programs are now being conducted within a complex political system. Each subsystem (public agency, institution, political interest group, etc.) added to the programs of Extension economists increases administrative complexity geometrically, not linearly. The team approach appeals to one's democratic principles and desire for the consideration of opposing views. While each con-

cerned subsystem may not have a "representative" on the team, each is better assured of having its position recognized.

Duration, Fluidity, and Flexibility

The application of the team approach to Extension economics does not establish a fail-safe system. In fact, its application is laden with numerous limitations which must be acknowledged before any degree of success can be achieved. Some limitations result from the characteristic of all organizational structures—their tendency to become rigid and perpetual. Others are related to supervision and evaluation of the human contribution to the team effort. Finally, a series of operational questions may evolve which, if left unanswered, could greatly reduce the effectiveness of the team approach. These limitations and problems are discussed below, together with relevant guidelines and solutions.

An implied reference to a "team" denotes a working body with an independent operational status and an ability to transcend usual functional (and perhaps departmental) lines. However, little or no reference is generally made to the operational status of such a working body.

To prove ultimately successful, membership on a team must be fluid; i.e., new personnel are assigned to the team as needed, and others, upon completion of their particular function, return to their particular functional or departmental posts [9, p. 113]. This is not to imply that an Extension economist must necessarily drop his normal duties and work full time for the team until completion of its task or his contribution. It isn't an either/or situation. Both the agricultural economist's conventional tasks and his team effort may be carried out simultaneously. A team should be able to add new members when their potential contribution is high and drop them when their specific contributions have been made and there is no immediate need of their talents. Fluidity in team membership, therefore, allows the team to adjust rapidly to changing demands and requirements. Despite its fluidity, however, the team remains a viable unit for the duration of its task.

Many Extension economists fail to recognize the necessity of having a clearly defined end point when participating in a team project. Failure to establish an end point may result in an undefinable team duration wherein the team becomes a permanent part of the overall organization and struggles for its life long after it is no longer worth saving. This is not to exclude the possibility of a highly proficient team being assigned to successive projects, thereby extending its active duration.

Unfortunately, Extension is particularly susceptible to the "sins of immobility"; i.e., teams are established within Extension, membership tends to remain rigid, and professional dialogue is soon "burned out." The teams then fabricate problems (and programs) to assure their continued existence beyond their productive lives. To avoid this, administrators should perhaps delegate to a team the responsibility of attaining a "satisfactory" rather than a "perfect" solution to a problem. Differentiation between the two is, in large part, an area of judgment which is impossible until at least one solution appears. Nevertheless, such a designation is more indicative of a recognizable end point with definitive parameters within which the solution should fall and team life ended.

Finally, the team approach places primary emphasis on the mission or objective. Because of this mission orientation, the team members become a semi-selfsufficient entity within the general confines of the parent organization. Thorough understanding of the nature of its mission gives the multidisciplinary team a decided advantage over its more traditional divisional or departmental counterpart in that simultaneous efforts on more than one aspect of a broad problem are facilitated and phasing from one state of development to the next is made more easily. The latter results in part from the continuous indoctrination about project progress received by team members. There is no time wasted getting a "feel" of the project or exploring avenues of earlier investigation which happens with the interdepartmental approach. In short, the loss of this mission orientation is likely to result in a substantial reduction in the degree of flexibility inherent in the team approach [9 p. 114].

Supervision and Evaluation

Cosgriffe and Dailey were keenly aware of the critical importance of team supervision and evaluation [2, pp. 84–85]. They acknowledged that the team leader must display an ability to identify and measure membership commitment; further, an important part of their proposal is that the team leader should observe team members' choices of action and sanction those that support team effort.

Experience has shown, however, that when

the team approach is applied to Extension economics programs, obstructions appear with alarming frequency. First, it is likely that each team member finds himself under two administrative heads, i.e., his departmental or Extension supervisor and the team leader. This violates the unity-of-command principle and creates obvious administrative dilemmas. Second, the scalar principle is no longer applicable because the team does not lend itself to hierarchical concepts [4, p. 146]; i.e., team leaders and department or Extension administrators, while organizationally distinct, do not appear in an explicit scalar relationship. Finally, the meaningful line-staff relationships between the team and the rest of the organization have a tendency to disappear [9, p. 113].

The breakdown of these three administrative principles complicates the work of the team and an evaluation of its performance. Scott goes so far as to say that the developing scalar indeterminancy between team leaders and departmental administrators, ". . . . gives rise to a transactional climate where bargaining and compromise are common in resolving conflicts over the allocation of personnel and performance appraisal" [8, p. 132].

Supervision and evaluation under the team approach thus becomes more difficult. To cope with this increased difficulty, one may consider the use of a system of saturation measurement (similar to that used in many commercial bank audits). Instead of periodic supervisory measurement, a series of random team audits by specialists and colleagues outside the team is conducted. Using Cosgriffe and Dailey's observation criteria, the evaluators could then measure team progress and efficiency of resource use, an ability greatly needed by Extension administrators. This method of evaluation could be expected to reduce intrateam conflict and the destructive influence of Scott's administrative "bargaining" noted earlier. Such a random audit evaluation system would also serve to assure team leaders that team performance is being observed and enable them to communicate to their team members the importance of establishing short- and long-term goals against which progress could be more easily measured. Team leaders themselves would be encouraged to incorporate into team project proposals some schedule showing intermediate progress points and definitive endpoint criteria, thereby blocking a meaningless prolongation of the team.

Other Problems

If teamwork is to become a major component of Extension economics programs, it will require changes at all levels of program supervision, planning, and conduct. Large-scale changes in any organization involve at least two operational problems: (a) structural resistance, i.e., a reluctance to change the line of command, administrative scope, etc.; and (b) human resistance [10, p. 686]. While the first appears only in the early stages of the introduction of change, the latter is longer lasting, occurs at all levels of the organization, and is quite often found in its most advanced form among the very administrators whose cooperation is essential. In this regard, one must recognize that the human problem in introducing change often exists not as an objection to the goal but rather in the perceived probability of its attainment. A second reason for human resistance is the vulnerability of one's professional position relative to the success or failure of the change. The human side of the required change in Extension economics programs can create a severe test of an administrator's understanding of communication and motivation. He must not only hear what is being said; he must also be able to understand why it is being said. His response is conditioned both by his own perception of the change and by his understanding of others' perception of it.

The team approach, when applied to Extension economics programs, also produces a number of not readily answerable questions:

(1) Where will the team members come from? Unless an individual is a "standby reservist," that is, unless he is essentially excess personnel pending a team assignment, he must be assigned some activity that can be economically justified. Extension cannot afford any excess fat in its personnel complement and has no excess positions available for the staffing of teams. Hence the individual's major Extension assignment is likely to suffer while he is serving on a team either from the lack of a replacement or from one with insufficient background and knowledge.

(2) Once a project has been completed or a team member's contribution is ended, how effectively will he return to his original assignment? Productivity is likely to be lost as the person switches back and forth.

(3) Can faculty positions and assignments be flexible enough that the academic department

will have available a pool of qualified team members?

(4) Can academic criteria for advancement be made sufficiently comprehensive and flexible to reward an individual equally for Extension service and the often more highly regarded categories of teaching and research?

The team approach may also create some unusual problems for supporting agencies. The financial office, for example, is soon confronted with more complicated funding and allocation requirements. First, periodicity loses its validity in communicating with finance officers when either the project or the team's life span may be in terms of days, months, or years. This indeterminate life span of a team and the lack of necessary fiscal information (cost and allocation standards) provides no control points such as those existing in the periodic closing of normal organizational records and accounts. Second, existing fiscal expense classification systems based upon natural functional or departmental lines require some modification when authority is diverted to the team level. Finally, recognition of team productivity (and resource deficiencies) may also become apparent only upon the dissolution of the team. During the active life of the team, therefore, finance officers are apt to fail to see the relevancy of set objectives, alternative strategies, and their financial support requirements [3, pp. 111—121].

Conclusion

If our administrative soothsayers are correct, during the next ten years Extension economists will find themselves involved with programs vastly different from today's [6, pp. 13–16]. For example, problems related to recreation, community resource development, environmental quality, and other socioeconomic elements will be of vital concern to the Extension Service. In only a few agriculturally-related Extension programs will agricultural economists be able to retain a degree of professional autonomy. When in search of solutions to those broader social and economic problems, Extension economists will find it not only desirable, but mandatory, to seek advice and assistance from other professional disciplines. Professional identity will be lost as the team approach to problem solution becomes a more dominant feature of Extension's efforts. Each team (or P.M.O.), for example, will be mission-oriented and multidisciplinary in composition.

This paper supports the application of the team approach to Extension economics programs. To facilitate its adoption, an efficient system of personnel transfer from academic department to Extension team (and vise versa) should be established. Each team should (a) be able to add to or subtract from its membership in response to an existing need, (b) operate toward clearly defined end points in both time and accomplishment, and (c) adopt a system of saturation measurement for performance evaluation.

The benefits derived from the team approach will enable agricultural economists to participate more effectively in those Extension programs requiring contributions from numerous professional disciplines. The most notable benefits will appear in the form of an improved ability to deal with (1) the complex political system within which Extension now exists and (2) the greater need for interpersonal communications between and among Extension personnel and the people they serve.

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A Linear Alternative to Quadratic and Semivariance Programming for Farm Planning Under Uncertainty*

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Quadratic decision criteria for farm planning are theoretically appealing but difficult to handle computationally. This paper reviews the advantages of the quadratic approach and develops a linear alternative which, while retaining most of the desired features of the quadratic models, can be readily solved on conventional linear programming codes with the parametric option.

LINEAR PROGRAMMING is widely recognized as a method for determining a profit maximizing combination of farm enterprises that is feasible with respect to linear fixed farm constraints. The conventional deterministic model ignores uncertainty,[1] however, and may lead to a farm plan that is unacceptable to a farm operator on the basis of previous experience. Uncertainty may arise in the linear programming model in forecasted costs, yields, and prices for individual activities; in activity requirements for fixed resources; and in the total fixed constraint levels.

This paper is concerned with uncertainties in activity costs, yields, and prices that affect the objective function of the conventional linear programming model. They may be summarized usefully as uncertainties in gross margins (gross returns net of variable costs). Quadratic programming, as developed by Markowitz [14, 15] for portfolio analysis, has been suggested as a useful method to consider gross margin uncertainty in farm planning [3, 10, 12, 16, 20]. But application of the technique depends on access to a special computer code of which there are few in existence with the desired features and capacity.

The quadratic programming model is reviewed in this paper and desired features of its expected income-variance criterion considered. Recognizing that quadratic programming must frequently be performed on time series or cross-sectional sample data, an alternative expected income-mean absolute deviation criterion is proposed. This criterion leads to a linear model that can be solved by parametric linear programming yet retains many of the desired features of the expected income-variance criterion. Conditions for a direct relationship between the variance and mean absolute income deviation are also discussed, in which the mean absolute income deviation can actually be viewed as a reasonable substitute for the variance in developing efficient income-variance farm plans. Finally, the properties of the expected income-mean absolute deviation criterion are explored as it relates to Markowitz's semivariance model [15].

Quadratic Programming

The expected income-variance ($E-V$) criterion of quadratic programming assumes that a farmer holds preferences among alternative farm plans solely on the basis of their expected income E and associated income variance V. This will be true if the farmer has an E-V utility function [15]. Quadratic programming further assumes that the iso-utility curves are convex, or that the farmer is a risk averter (Figure 1). That is, along every iso-utility curve $\partial E/\partial V>0$ (the farmer would prefer a strategy with higher V only if E were also greater) and $\partial E^2/\partial V^2>0$ (this compensation must increase at an increasing rate with increases in V). Markowitz [15] has shown that it is sufficient for the farmer's von Neuman and Morgenstern [22] utility-of-income function to be quadratic and convex down for this condition to hold. Tobin [21] has established more general conditions, but these hold only when income distributions are normally distributed [5].

Given these assumptions, a farmer rationally should restrict his choice among those farm plans for which the associated income variances are minimum for the given expected income levels. The purpose of quadratic programming is to develop the set of feasible farm plans having the property that variance V is minimum for associated expected income level E. Such plans are called efficient E-V pairs and

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[1] Uncertainty is used in this paper to denote situations in which knowledge of future events is limited to estimates of both possible outcomes and relative frequencies.

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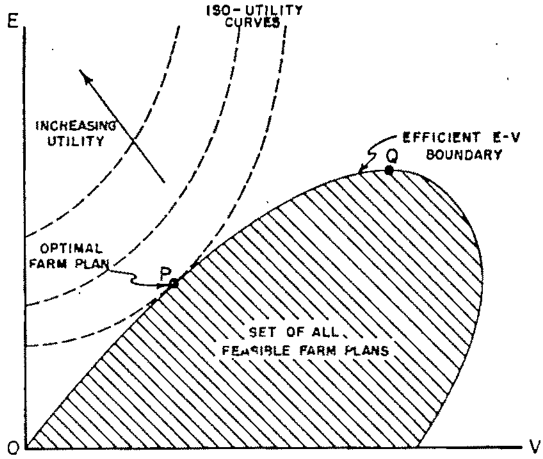

Figure 1. The optimal *E-V* farm plan

define an efficient boundary over the set of all feasible farm plans (segment OQ in Figure 1).

Since short-run planning models assume farm overhead costs to be constant for the length of the planning horizon, the income distribution of a farm plan is totally specified by the total gross margin distribution. The quadratic programming model can therefore be defined as follows in terms of activity gross margins:

$$\text{(1)} \qquad \text{Minimize } V = \sum_{j=1}^{n} \sum_{k=1}^{n} x_j x_k \sigma_{jk}$$

such that

$$\text{(2)} \qquad \sum_{j=1}^{n} f_j x_j = \lambda \qquad (\lambda = 0 \text{ to unbounded})$$

and

$$\text{(3)} \qquad \sum_{j=1}^{n} a_{ij} x_j \leq b_i \qquad (\text{for all } i, i = 1 \text{ to } m)$$

$$\text{(4)} \qquad x_j \geq 0 \qquad (\text{for all } j, j = 1 \text{ to } n)$$

where

x_j = the level of the jth activity;
f_j = the expected (forecasted) gross margin of the jth activity;
σ_{jk} = the covariance of gross margins between the jth and kth activity when $j=k$ and the variance coefficient of gross margins for the jth activity when $j \neq k$;
a_{ij} = the technical requirements of the jth activity for the ith resource or constraint;
b_i = the ith constraint level;
n = the number of activities;
m = the number of constraints;
λ = a scalar.

The sum $\sum^n_{j=1} f_j x_j$ is the expected total gross margin E, and $\sum^n_{j=1} \sum^n_{k=1} x_j x_k \sigma_{jk}$ is the expected variance V. By parameterizing λ from zero to unbounded, a sequence of solutions are obtained of increasing total gross margin and variance until the maximum possible total gross margin under the resource constraints has been attained.[2] Solutions are obtained for critical turning points in the solution basis, such that for the current total gross margin E, determined by λ, the variance V is minimum. These solutions are sufficient to define the efficient E-V boundary since efficient E-V plans for intermediate levels of E can be derived by linear interpolation on adjacent turning point solutions.

Given a set of efficient farm plans the acceptability of any particular one to an individual farmer will depend on his preferences among various expected income and associated variance levels as described by his E-V utility function. When this function can be measured, a unique farm plan can be rigorously identified which offers the farmer highest utility [13, 15]. This is the efficient farm plan P in Figure 1. However, since progress toward the specification of such utility functions is apparently slow, the better alternative for the immediate future seems to lie in obtaining the set of efficient farm plans and allowing the farmer to make the final choice. This approach is also more flexible in avoiding too rigid a specification of the utility function and perhaps compensates to some extent for situations where income variance is not the best measure of uncertainty. Further, if other socioeconomic factors enter the utility function in addition to E and V, the farmer is free to choose the plan he most prefers in relation to a multiplicity of goals.

Data Requirements of Quadratic Programming

The quadratic programming model (1)–(4) requires knowing a priori the mean gross margins for each activity (f_j; $j=1$ to n) and the corresponding variances and covariances

[2] The solution for maximum λ is actually the linear program solution for the forecasted gross margins. For a geometric analysis of these relationships see How and Hazell [12].

(σ_{jk}; j, $k=1$ to n). As these parameters are unknown, it is necessary to obtain estimates using time series or cross-sectional data of observed gross margins. Under certain circumstances subjective parameter values may be available from the farm operator, and farm operators may prefer to accept plans derived from their own subjective parameter values. However, this type of information is very difficult to obtain for a complex farm business, and it is unlikely that all variance-covariance parameters are specified. A practical compromise is to use estimated values at the outset but to make adjustments, if necessary, with available subjective information.

Regardless of the estimation procedure, estimated means and variance-covariance coefficients are generally regarded as nonstochastic parameters in the quadratic programming model, even though statistical properties of the estimates may be known.[3] This consideration is rarely discussed in quadratic programming studies, but estimated coefficients are implicitly assumed to be either subjective or nonstochastic parameters. Unless the original sample estimates are adjusted or confirmed by farmer expectations, however, such assumptions are not strictly valid.

To illustrate the standard estimation procedure, the variance V in equation (1) is replaced by

$$(5)\qquad \sum_{j=1}^{n}\sum_{k=1}^{n} x_j x_k \left[\frac{1}{s-1}\sum_{h=1}^{s}(c_{hj}-g_j)(c_{hk}-g_k)\right]$$

where $h=1$ to s denote s observations in a random sample of gross margins, and g_j is the sample mean, $1/s\ \sum_{h=1}^{s} c_{hj}$, of the gross margins for the jth activity, ($j=1$ to n) which may differ from the forecasted value f_j if subjective information is incorporated for these values.[4] Taking the summation over h to the left and factoring, the estimated variance is

$$(6)\qquad \frac{1}{s-1}\sum_{h=1}^{s}\left[\sum_{j=1}^{n} c_{hj}x_j - \sum_{j=1}^{n} g_j x_j\right]^2$$

Now $\sum_{j=1}^{n} c_{hj}x_j$ is the total gross margin of a particular farm plan evaluated with observed gross margins for the hth sample observations, and $\sum_{j=1}^{n} g_j x_j$ is the total gross margin for the same farm plan evaluated with sample mean gross margins. Income variance can therefore be calculated with sample data either indirectly from the individual activity gross margin distributions, equation (5), or directly from the total gross margin distribution, equation (6). Thus, when subjective expectations are at most available for the forecasted gross margins, equation (6) can be substituted as an estimate of equation (1) in the quadratic programming model.

Covariance relationships (particularly when negative) are fundamental for effective diversification among farm enterprises as a means of hedging against uncertainty [9]. However, when using the estimation procedure defined in equation (5) and hence (6), it is readily seen that the covariance relationships depend upon the patterns of interrelationships captured between the sample set of mutually exclusive vectors of possible activity gross margin outcomes together with their relative frequencies of occurrence. In other words, when defined on sample data the quadratic programming model recognizes gross margin interrelationships by recognizing the mutually exclusive nature of the sample gross margin vectors. This means that linear combinations of the sample vectors are ruled out so that sets of gross margin outcomes are not anticipated in the solution procedure that are worse or better than any individual sample vector. But many other measures of income dispersion exist besides the variance which are capable of using this same information and which lead to efficient two-parameter models [8].

Advantages of the *E-V* Criterion

The *E-V* criterion is particularly attractive for farm management research for the following reasons:

(a) The criterion is consistent with probability statements with respect to the likelihood of occurrence of different income levels for a given farm plan [18]. If total gross margins can be expected to be approximately normally distributed,[5] and if the variance-covariance

[3] This is analogous to the widespread recommendation of optimal input levels from statistically estimated production functions without regard to the sampling distribution of such estimates.

[4] This, because the forecasted gross margins of an activity can be changed from its sample mean without affecting the sample variance.

[5] The total gross margin distribution of a farm plan will be approximately normal if the individual activity gross margin distributions are approximately normal. This is a demanding requirement and fortunately the Central Limit Theorem is applicable when sufficient numbers of activities enter farm plans and the activity gross margins are independent over time.

coefficients used can be regarded as nonstochastic or subjective parameters, then such probability statements are easily derived using tables for the normal deviate statistic [3, 12, 16]. Baumol [2] has used this approach to confine attention to those efficient E-V solutions for which an appropriate lower probability boundary is downward sloping for increases in E. Actually, the t distribution may be used to derive similar statements when only sample variance-covariance coefficients are available providing the forecasted gross margins are nonstochastic or subjective parameters.

(b) The variance V is totally specified by the variance-covariance coefficients; and when subjective values of these parameters are available, the variance is no longer estimated from the sample of observed gross margin outcomes. That is, equation (1) is applicable and need not have a direct relationship with equation (5) or (6).

(c) The criterion is consistent with the Separation Theorem and allows more general solution to the farm diversification problem given a riskless option [13].

Problems arise in applying the criterion, however, in that available quadratic programming computer codes with the necessary parametric option are of limited dimensions and uncertain performance.[6] The question arises whether alternative criteria might not be available which have most of the desired properties of the E-V criterion but which are easier to handle computationally. The expected income-mean absolute income deviation criterion is proposed to this end.

The Expected Income-Mean Absolute Income Deviation Criterion

Assuming the same sample data are available as for equation (6), the mean absolute income deviation (denoted by A) may be defined as follows.

$$(7) \qquad A = \frac{1}{s} \sum_{h=1}^{s} \left| \sum_{j=1}^{n} (c_{hj} - g_j) x_j \right|$$

A is an unbiased estimator of the population mean absolute income deviation [11].

Using A as a measure of uncertainty, it is reasonable to consider E and A as the crucial parameters in the selection of a farm plan and to define efficient E-A farm plans as those having minimum mean absolute income deviation for given expected income level E. As with the E-V criterion, such an E-A criterion is consistent with the Separation Theorem and with the derivation of probability statements with respect to the likelihood of occurrence of different income levels for a given farm plan. Assuming approximate normality and that the forecasted gross margins are nonstochastic or subjective parameters, the latter may be derived by use of tables for Herrey's H statistic [11]. They may also be derived using the variance of the farm plan calculated ex post using equation (6).

The mean absolute income deviation also considers interrelationships between activity gross margins by recognizing the mutually exclusive nature of the sample vectors of activity gross margin outcomes together with their associated relative frequencies; but unlike the variance, this requirement cannot be relaxed when subjective information is available. Subjective information can be incorporated only through judicious selection of important gross margin outcomes and assignment of associated probabilities. In this respect the criterion is more closely related to the parametric game models [7] where the possible sets of gross margins are called states of nature and can be carefully defined along the lines suggested by McInerney [17]. When using subjective data in this way it is necessary to regard the data as a population.

The E-A criterion has an important advantage over the E-V criterion in that it leads to a linear programming model in deriving efficient E-A farm plans. To see this, observe that in equation (7) $1/s$ is a constant and it is therefore sufficient to minimize sA subject to the constraints (2), (3), and (4). To convert sA to a legitimate linear programming objective function, a procedure similar to that used by Ashar and Wallace [1] may be used. Define new variables

$$y_h = \sum_{j=1}^{n} c_{hj} x_j - \sum_{j=1}^{n} g_j x_j \qquad (\text{for all } h,\ h = 1, \cdots, s),$$

such that

$$y_h = y_h^+ - y_h^-$$

and

[6] Available programs tend to suffer severely from computer rounding errors arising with the parametric subroutine, and problems can arise with multiple solutions when the variance-covariance matrix is only positive semidefinite rather than positive definite as required [13].

$$y_h^+, y_h^- \geq 0;$$

that is, such that y_h, $(h=1, \cdots, s)$, are unconstrained in sign. Then, if y_h^+ and y_h^- are selected in some minimal way so that one or the other is zero, $|y_h| = y_h^+ + y_h^-$, $(h=1, \cdots, s)$. But we can do this concurrently while seeking optimal x_j, $(j=1, \cdots, n)$, in the following linear programming model.

$$\text{(8)} \qquad \text{Minimize } sA = \sum_{h=1}^{s} (y_h^+ + y_h^-)$$

such that

$$\text{(9)} \qquad \sum_{j=1}^{n} (c_{hj} - g_j)x_j - y_h^+ + y_h^- = 0 \qquad \text{(for all } h, h = 1, \cdots, s)$$

and

$$\text{(10)} \qquad \sum_{j=1}^{n} f_j x_j = \lambda \qquad (\lambda = 0 \text{ to unbounded})$$

$$\text{(11)} \qquad \sum_{j=1}^{n} a_{ij} x_j \leq b_i \qquad (\text{for all } i, i = 1, \cdots, m)$$

$$\text{(12)} \qquad x_j, y_h^+, y_h^- \geq 0 \quad (\text{for all } h, j)$$

The model can be solved on conventional linear programming codes with the parametric option and provides a set of farm plans that are efficient for expected income and mean absolute income deviation. Since the model minimizes sA, it will be referred to hereafter as the Minimization of Total Absolute Deviations (MOTAD) model.

Now, for a given farm plan,

$$y_h^+ = \left| \sum_{j=1}^{n} (c_{hj} - g_j)x_j \right|$$

when $\sum_{j=1}^{n} (c_{hj}-g_j)x_j$ is positive and zero otherwise. Thus, $\sum_{h=1}^{s} y_h^+$ is the sum of the absolute values of the positive total gross margin deviations around the expected return based on sample mean gross margins. Similarly,

$$y_h^- = \left| \sum_{j=1}^{n} (c_{hj} - g_j)x_j \right|$$

when $\sum_{j=1}^{n} (c_{hj}-g_j)x_j$ is negative and zero otherwise, so that $\sum_{h=1}^{s} y_h^-$ is the sum of the absolute values of the negative total gross margin deviations around the expected return based on sample mean gross margins. It follows then that $\sum_{h=1}^{s} y_h^+$ must be exactly equal to $\sum_{h=1}^{s} y_h^-$ if g_j, $(j=1, \cdots, n)$, are sample mean gross margins. This suggests an alternative formulation for the MOTAD model based on minimizing only the sum of the absolute values of the negative total gross margin deviations $\sum_{h=1}^{s} y_h^-$. This is easily done in the following linear programming model.

$$\text{(13)} \qquad \text{Minimize } \sum_{h=1}^{s} y_h^-$$

such that

$$\text{(14)} \qquad \sum_{j=1}^{n} (c_{hj} - g_j)x_j + y_h^- \geq 0 \qquad (\text{for all } h, h = 1, \cdots, s)$$

and

$$\text{(15)} \qquad \sum_{j=1}^{n} f_j x_j = \lambda \qquad (\lambda = 0 \text{ to unbounded})$$

$$\text{(16)} \qquad \sum_{j=1}^{n} a_{ij} x_j \leq b_i \qquad (\text{for all } i, i = 1, \cdots, m)$$

$$\text{(17)} \qquad x_j, y_h^- \geq 0 \qquad (\text{for all } h, j)$$

This formulation can also be solved by conventional linear programming codes with the parametric option and leads to identical results as the model (8)–(12) except that the numeric value of the objective function is $\frac{1}{2}sA$ rather than sA. Note that while the MOTAD formulation (8)–(12) generally involves $n+2s$ real activities, the formulation (13)–(17) requires only $n+s$ real activities. Since both formulations have $m+s+1$ constraints if the nonnegativity requirements are ignored, the MOTAD formulation (13)–(17) is to be preferred in terms of computational efficiency in deriving efficient *E-A* farm plans.

In the absence of a measured *E-A* utility function, final selection of a farm plan from an efficient *E-A* set must be left to the individual farmer concerned. When results are presented in probabilistic terms a farmer is unlikely to have any greater difficulty in considering an efficient *E-A* set of farm plans than an efficient *E-V* set.

The MOTAD Model as a Substitute for Quadratic Programming

So far the *E-A* criterion has been proposed as an alternative to the *E-V* criterion in the sense that a farmer's preferences among alternative farm plans might be described by an *E-A* utility function. Under some conditions, however, choice between these criteria is less

important in defining a programming model since they may be expected to lead to similar or identical farm plans. More specifically, suppose (a) that the total income variances and mean absolute income deviations are estimated from sample data (though this may be corrected for any price and yield trends or cycles and for subjective expectations with respect to the means) and (b) that the populations of possible income outcomes for farm plans are normally distributed. Then, by considering the sampling distribution of estimated variance and mean absolute income deviation parameters, it is possible to examine the statistical properties of the mean absolute income deviation as a substitute for the variance in deriving efficient E-V farm plans.

It has long been established that when sampling from a normal distribution, the population standard deviation can be estimated with the statistic $d(\pi s/2(s-1))^{1/2}$ where s is the number of observations in the sample, $\pi=22/7$, and d is the estimated mean absolute deviation (m.a.d.) [11]. This statistic is also an estimate of the population standard deviation when the population is only approximately normally distributed [4]. Now since $(\pi s/2(s-1))^{1/2}$ is a constant, and we are considering A as a sample m.a.d., it is apparent that when the total gross margin distributions are approximately normal, the MOTAD model generates efficient farm plans for this estimate of the population income standard deviation (s.d.). Quadratic programming derives the efficient farm plans for the more usual sample standard deviation estimate of the population standard deviation; hence, any differences in the reliability of results from the two models for the same sample data will, given normality, depend upon differences in the properties of these estimators.

Both estimators are unbiased, provided that $s-1$ degrees of freedom are used in computing the sample variance-covariance coefficients and s degrees of freedom in computing A. Differences may arise however, in the relative efficiency of the two estimators.

Fisher [6] has shown that for large sample sizes the estimated mean absolute deviation is only 88 percent as efficient as the estimated standard deviation in estimating the population standard deviation. That is, the relative asymptotic efficiency of the sample mean absolute deviation is 88 percent.

Mathematical properties for small samples are less established, though these are the most interesting for farm planning when working with short-time series data. A classical manual simulation study was reported by Davies and Pearson [4] in 1934. Using approximately normally distributed data from a cement mortar composition study, they tabulated the following standard errors of estimates in population standard deviation units for single samples:

Estimate of population s.d. based on:	Sample size								
	2	3	4	5	6	10	15	20	50
Sample s.d.	.603	.463	.389	.341	.308	.232	.187	.161	.101
Sample m.a.d.	.756	.525	.430	.373	.334	.250	.201	.173	.108

The standard error of the sample mean absolute deviation was also found to tend to a value of 1.07 times the standard error of the sample standard deviation. The square of this ratio is approximately 1.14 which is consistent with Fisher's asymptotic efficiency value of 88 percent (that is, (100/1.14 percent)). Similar calculations for the above data give some indication of the relative efficiency of the sample mean absolute deviation for small samples:

	Sample size								
	2	3	4	5	6	10	15	20	50
Relative efficiency of sample m.a.d. (percent)	64	77	82	84	85	86	87	87	87

Since both estimators are unbiased and asymptotically normally distributed, these figures provide a rough but useful guide to the relative reliability of the two estimators [4]. The sample standard deviation always comes out best, being the minimum variance estimator, but its superiority is sufficiently marginal for sample sizes greater than 4 or 5 to justify consideration of the sample mean absolute deviation.

In the quadratic programming problem we seek to select a subset of farm plans from the set of all feasible plans having the property that, for given population E, the population variance (or equivalently, the population standard deviation) is minimum. In using sample data two sources of error may arise. We may select the wrong farm plans and/or we may incorrectly estimate the efficient E-V population function. Incorrect selection of the farm plans will in general imply incorrect estimation of the efficient E-V population function, but the reverse is not necessarily true. Errors in the selection of farm plans depend not only on the imputed variance for given E but also on the sensitivity of the "true" efficient farm

plans to changes in V for given E and on the rigidity of the farm constraints in forcing the farm plans. Either consideration could lead to the correct farm plans despite errors in the imputed variances, though the latter is more likely.

An inefficient estimator of V implies greater possible error in both sources. Quadratic programming utilizes the most efficient estimator of V, hence is subject to the least expected error. The MOTAD model on the other hand uses an estimator of V that at best may be only 88 percent as efficient, and in general the results cannot be expected to be as reliable. Note that both models use the same estimate of E; hence there can be no discrepancies in reliability on this ground. However, the possible rigidity of farm constraints in forcing farm plans may considerably enhance the reliability of the MOTAD model in selecting the correct farm plans. Further, since the variance of farm plans derived with the MOTAD model can be calculated ex post using equation (6), it is quite possible to generate almost identical farm plans and E-V efficiency functions for the same sample data with both techniques. This conclusion has been borne out by the author through actual application of both models to fresh market vegetable farms in New York and Florida operating under stringent market outlet constraints for individual crops. A less constrained and therefore more interesting example is presented at the end of this paper. Such results cannot be generalized, however; and in considering the MOTAD model as a substitute for quadratic programming in developing efficient E-V farm plans, it is well to be prepared for some loss in the reliability of the results.

It must be stressed that the above relationships hold only when the populations of possible income outcomes for farm plans are approximately normally distributed and when estimates of V and A are based solely on sample data. These requirements are not unreasonable in practice. Most farm situations that justify sophisticated programming techniques are likely to involve a sufficient number of activities so that approximate normality holds by the Central Limit Theorem. Further, subjective information can rarely be gleaned from farmers to supplement sample data on the dispersion and interrelationships of gross margin distributions. It seems reasonable to conclude that the MOTAD model may have considerable potential as an alternative computational procedure to quadratic programming in deriving efficient E-V farm plans, particularly when an adequate quadratic programming code is not available. The MOTAD model also has additional features that make it desirable as a substitute computational procedure, perhaps even when a quadratic programming code is available. First, it may lead to much smaller problems for complex farm organizations. The quadratic programming model generally invokes $m+n$ constraints and real activities, but the MOTAD model formulation (13)–(17) requires only $m+s+1$ constraints and $m+s$ real activities.[7] Second, while quadratic programming does provide dual information on the marginal values of constraints and activities, these values do not hold over any specified intervals [19]. The MOTAD model is therefore better adapted for post-optimality analysis.

When subjective information is available with respect to the dispersion and interrelationships of activity gross margins (a farmer may be willing to offer information about the probabilities of different gross margin outcomes, for example), it can be incorporated only at the expense of losing the sampling properties of input data, and the above relationships do not hold. While this does not preclude the possibility of getting similar results from the quadratic program and MOTAD models, the latter cannot be rigorously justified as a substitute to quadratic programming in deriving efficient E-V plans.

Semivariance Considerations

The variance as a measure of uncertainty weights total gross margin observations according to the square of their deviation from the mean. That is, E-V utility implies increasing marginal disutility the larger the total gross margin deviation from the mean. A direct consequence of this weighting procedure is that the contribution of negative total gross margin deviations to the variance need not be equal to the contribution of the positive total gross margin deviations. More specifically, assuming sample data, the negative semivariance

$$\frac{1}{s-1}\sum_{h=1}^{s}\left[\mathrm{Min}\left\{\sum_{j=1}^{n}(c_{hj}-g_j)x_j,\ 0\right\}\right]^2$$

need not be equal to the positive semivariance

$$\frac{1}{s-1}\sum_{h=1}^{s}\left[\mathrm{Max}\left\{\sum_{j=1}^{n}(c_{hj}-g_j)x_j,\ 0\right\}\right]^2.$$

[7] The author is indebted to Wilfred Candler for this suggestion.

In fact, an inequality will generally hold unless the population total gross margin distributions are symmetric.

This is important because even when an individual does weight income deviations on a quadratic basis there may be no a priori reason to assume that he attaches any disutility to positive income deviations, so that using an E-V criterion may lead to unnecessarily conservative farm plans. Markowitz [15] suggested that when total gross margins cannot be expected to be symmetrically distributed, an expected return-negative semivariance criterion might provide a better approximation of an individual's utility function. In effect, Markowitz suggested minimizing the negative semivariance subject to the constraints (2), (3), and (4) to generate a set of efficient E-negative semivariance farm plans. However, such a model can be solved only through Monte Carlo simulation techniques which are unlikely to be a practical procedure for most farm planners.

These problems do not arise if an individual weights income deviations on a linear basis, as presumed in the E-A criterion, because the negative income deviations always make an equal contribution to the positive income deviations in the mean absolute deviation measure of uncertainty. That is,

$$\frac{1}{s}\sum_{k=1}^{s} y_k^- = \frac{1}{s}\sum_{k=1}^{s} y_k^+$$

regardless of the shape of the total gross margin distributions. Thus, even if a farmer does not attach any disutility to positive total gross margin deviations, the E-A criterion is still appropriate in defining a programming model since it leads to the same efficient set of farm plans as a model based on an expected return-mean absolute negative deviation criterion. This fact was used in constructing the MOTAD formulation (13)–(17). It follows that if the E-A criterion is an acceptable approximation to a farmer's utility function, the MOTAD model provides a single alternative to both the quadratic and semivariance models for all types of total gross margin distributions.

While the E-A criterion avoids semivariance type problems, it does mean that a linear substitute to the semivariance model cannot be based on absolute deviations for generating efficient E-negative semivariance farm plans when a quadratic utility weighting procedure is appropriate. In this case the only linear alternatives appear to be the parametric game models [7], but their statistical properties as possible computational substitutes to the semivariance model are not known.

A Numeric Illustration

To illustrate some of the concepts discussed, the quadratic programing and MOTAD models are applied to a small numeric example.

The example comprises four vegetable activities: carrots (x_1), celery (x_2), cucumbers (x_3), and peppers (x_4); and three less-than or equal-to constraints on the available acreage of land (b_1), hours of labor (b_2), and a rotational and market outlet constraint (b_3). The technical requirements coefficient matrix A and constraint vector b are

$$A = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 25 & 36 & 27 & 87 \\ -1 & 1 & -1 & 1 \end{bmatrix}, \qquad b = \begin{bmatrix} 200 \\ 10{,}000 \\ 0 \end{bmatrix}$$

The constraint b_3 requires that the total acreage of celery and peppers be less than or equal to the total acreage of carrots and cucumbers.

A time series of gross margins was obtained from an actual fresh market vegetable farm in Florida (Table 1). The estimated covariance matrix is

$$\begin{bmatrix} 11{,}264 & -20{,}548 & 1{,}424 & -15{,}627 \\ -20{,}548 & 125{,}145 & -27{,}305 & 29{,}297 \\ 1{,}424 & -27{,}305 & 10{,}585 & -10{,}984 \\ -15{,}627 & 29{,}297 & -10{,}984 & 93{,}652 \end{bmatrix}$$

which explicitly expresses the interrelationships captured between the six row vectors of Table 1. Sample mean gross margins are used as forecast values.

A tableau of constraints and real activities for the MOTAD model formulation (13)–(17) is presented in Table 2. Note that the activity

Table 1. Activity gross margins per acre for example problem

Year	x_1	x_2	x_3	x_4
	dollars			
t_1	292	−128	420	579
t_2	179	560	187	639
t_3	114	648	366	379
t_4	247	544	249	924
t_5	426	182	322	5
t_6	259	850	159	569
Average	253	443	284	516

Table 2. The MOTAD model for example problem

Row and unit	x_1	x_2	x_3	x_4	y_1^-	y_2^-	y_3^-	y_4^-	y_5^-	y_6^-	Constraint
A (dollars)					1	1	1	1	1	1	Minimize
b_1 (acres)	1	1	1	1							$\leq$ 200
b_2 (hours)	25	36	27	87							$\leq$ 10,000
b_3 (acres)	−1	1	−1	1							$\leq$ 0
t_1 (dollars)	39	−571	136	63	1						$\geq$ 0
t_2 (dollars)	−74	117	−97	123		1					$\geq$ 0
t_3 (dollars)	−139	205	82	−137			1				$\geq$ 0
t_4 (dollars)	−6	101	−35	408				1			$\geq$ 0
t_5 (dollars)	173	−261	38	−511					1		$\geq$ 0
t_6 (dollars)	6	407	−125	53						1	$\geq$ 0
E (dollars)	253	443	284	516							= λ

entries for the rows t_h, $(h=1, \cdots, 6)$, are the activity gross margin deviations from their sample means in the hth year. The set of efficient E-A solutions occurring at change in basis for this model was obtained (Table 3), as were the quadratic program solutions (Table 4). In both cases the last solution is identical with a conventional linear programming solution obtained for the average gross margins.

The example chosen permits considerable flexibility in the cropping plans while retaining feasibility to the farm constraints. Further, there are insufficient activities to expect total gross margins to be approximately normally distributed by the Central Limit Theorem. These considerations suggest that the MOTAD model need not be a good substitute for the quadratic programming model in generating the set of efficient E-V farm plans for this problem. However, a comparison of quadratic programmed and MOTAD model solutions (Table 4) indicates a surprising similarity of results. In particular, although some discrepancies in crop acreage occur, these are not sufficient to have any marked effect on the corresponding standard deviations. In fact, the E-V pairs are almost identical for the two models.

Conclusions

A linear decision criterion using the expected return and the mean absolute income deviation has been proposed as an alternative to the E-V and E-semivariance criteria for farm planning under gross margin uncertainty. The suggested criterion utilizes similar data on possible activity gross margin outcomes and has desirable properties as a decision criterion for farm management research and extension purposes. In addition, it leads to farm planning models that can be solved on conventional linear programming codes with the parametric option. This enables easier and less expensive solution of large-dimensioned problems and permits better post-optimality analysis. Under quite common empirical conditions, the proposed MOTAD model for the E-mean absolute income deviation criterion has been justified as an approximate computational procedure for deriving efficient E-V farm plans when a good quadratic program is not available.

Table 3. The MOTAD model results for example problem

Cropping plan	I	II	III	IV	V
E (dollars)	62,769	73,574	77,329	77,529	77,996
A (dollars)	2,753	9,301	12,533	12,787	13,479
Standard deviation (dollars)	4,706	16,358	21,442	21,792	22,372
x_1 (acres)	72.26	32.85	19.15	16.59	—
x_2 (acres)	26.80	28.03	28.46	26.80	27.45
x_3 (acres)	83.92	81.64	80.85	83.41	100.00
x_4 (acres)	17.02	57.48	71.54	73.20	72.55

[a] Estimate based on equation (5).

Table 4. A comparison of results obtained with the quadratic program and MOTAD models for example problem

Cropping Plan	Model	I	II	III	IV
E (dollars)		62,609	77,142	77,354	77,996
Standard deviation (dollars)	Q[a]	4,624	20,882	21,182	22,372
	M[b]	4,694	21,187	21,485	22,372
x_1 (acres)	Q	68.67	4.32	—	—
	M	72.08	19.83	18.83	—
x_2 (acres)	Q	28.26	37.21	36.14	27.45
	M	26.73	28.44	28.25	27.45
x_3 (acres	Q	88.23	95.68	100.00	100.00
	M	83.71	80.89	81.17	100.00
x_4 (acres)	Q	14.85	62.77	63.85	72.55
	M	16.97	70.84	71.75	72.55

[a] Q denotes quadratic program solutions which occurred at change in basis.
[b] M denotes corresponding MOTAD model solutions for same levels of E.

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A Simultaneous-Equation Model of Spatial Equilibrium and Its Application to the Broiler Markets*

Tsoung-Chao Lee and Stanley K. Seaver

The simultaneous-equation approach is used to formulate a positive spatial equilibrium model consisting of linear behavioral and definitional equations and bilinear equilibrium conditions. In contrast to the normative Takayama-Judge quadratic spatial equilibrium model, the positive model leads to a smaller simplex tableau and permits evaluation of the effect of predetermined variables on spatial equilibrium. The model is applied to structural changes of broiler markets. Spatial equilibrium multipliers are presented to show the interregional competition of the existing broiler markets.

In recent years spatial equilibrium analysis has been formulated as a quadratic programming problem. Takayama and Judge [12] derived the model by maximizing the so-called "net social payoff" subject to the linear demand and supply functions. Their study is largely conceptual in the sense of assuming that linear demand and supply functions are known or given. Many researchers [7, 8, 14], when applying this model, have estimated demand and supply functions based on methods that are exogenous to the structure of spatial equilibrium. The supply function of each market may be estimated as a single regression equation independent of the supply functions in other markets and of the demand function in the same market [14]. Or market supply functions may be estimated by the micro-to-macro buildup approach from the linear programming step supply functions [8]. The demand functions are usually derived [7, 8] from Brandow's demand elasticities or slopes that were estimated in 1961 [2].

In view of previous work, spatial equilibrium models are often used normatively to show how the output at many locations "should" flow to many consuming areas if competitive conditions are to be attained and costs minimized. However, no positive analysis of spatial equilibrium has been reported in the Journal. It should be emphasized that a positive analysis of spatial equilibrium should estimate the demand and supply functions simultaneously within the model in order to produce quantitative statements "describing" the existing competitive markets and to predict the future course of economic variables. Thus, one of the hypotheses in positive analysis is that the markets are spatially competitive, which of course is subject to statistical test.

Within the context of positive economics, equilibrium conditions and definitional equations place a restriction on the parameters that are being estimated. To deal with economic variables generated by a spatially competitive system that is dynamic, stochastic, and simultaneous, a simultaneous-equation technique is required. It should be noted that if a simultaneous solution of exogenously estimated structural equations were intended as a positive analysis, it would be subject to Haavelmo's criticism.[1]

Broiler markets, in our analysis, are considered spatially competitive. Broiler production in the southern states has been increasing tremendously since 1957, while the northeast region has changed from a surplus to a deficit area. It is believed that the change is associated with decreasing farm price of broilers and increasing feed price in the northeastern states relative to that of the southern states. In view of these changes we are interested in studying structural changes of the broiler economy. Specifically, the objective is to analyze the effect of a change in feed price in each region on (1) broiler production, (2) price of broilers, (3) shipment of broilers among regions, and (4) derived demand for feed.

In this paper (1) a general simultaneous-equation model of spatial equilibrium is presented and discussed, and (2) a specific model of spatial equilibrium is proposed to study the

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[1] "A most dangerous procedure in estimating parameters in systems of stochastic equations is to fit each equation separately without regard to the fact that the variables involved are, usually, assumed to satisfy, simultaneously, a number of other stochastic relations" [6].

structural change of broiler markets in the aggregate with emphasis on regional interelationship. There is no intention of studying the broiler industry at the producing or retail firm level.

Methodology

The simultaneous-equation model

Assuming n spatially separated markets or regions, we hypothesize the linear demand and supply functions for a single commodity in the ith region as

$$(1) \quad D_i = \alpha_i p_i + a_{i0}z_0 + a_{i1}z_1 + \cdots + a_{ik}z_k + u_i$$

and

$$(2) \quad S_i = \beta_i p_i + b_{i0}z_0 + b_{i1}z_1 + \cdots + b_{ik}z_k + v_i$$

where p_i is the price and the z's are predetermined variables such as income, factor input price, etc., and u_i and v_i are stochastic variables which may be assumed to have zero means, constant variances over time, and zero autocorrelations, but may not be independent of price. The parameters are α, β, a's and b's. There are n such supply and n such demand equations.

Since spatial equilibrium models consider the interregional flow of commodities, demand and supply may be decomposed into shipments:

$$(3) \quad D_j = \sum_i x_{ij} \qquad j = 1, 2, \cdots, n$$

and

$$(4) \quad S_i = \sum_j x_{ij} \qquad i = 1, 2, \cdots, n$$

where x_{ij} denotes quantity shipped from ith region to the jth region. There are n equations for each type of (3) and (4). Before reaching equilibrium, commodity flow is considered possible whenever the price differential in any pair of regions exceeds the transportation costs t_{ij}. Thus, whether the product in the ith region should be sold in the jth region depends on the following per unit loss (or per unit gain):

$$(5) \quad r_{ij} = t_{ij} - (p_j - p_i) \qquad \text{all } i, j$$

There are n^2 such definitional equations. Since in the same region the transportation cost is zero, only $n(n-1)$ equations are required to determine $n(n-1)$ interregional flows of commodities.

For a competitive equilibrium to hold, there must be no profit ($r_{ij}=0$) or there must be no flow of commodities ($x_{ij}=0$).[2] There are $n(n-1)$ equilibrium conditions:[3]

$$(6) \quad r_{ij}x_{ij} = 0 \qquad \text{for } i \neq j$$

In total there are $2n+2n^2$ equations with the same number of jointly dependent variables, which specifies a complete system of equations.[4]

The model as specified is for a single product case, but it may be generalized into multiproduct general equilibrium. Supply and demand functions may be formulated as functions of many commodity prices and some predetermined variables.

In summary, the spatial equilibrium model involves equations for demand and supply (1) and (2), commodity distributions (3) and (4), and equilibrium conditions (6), in which the loss variable (or profit margin) is defined in (5).

Identification and estimation

The demand and supply functions of the model are identifiable as long as transportation costs t_{ij}'s do not appear in the demand and supply functions. To obtain the consistent estimates of the parameters of demand and supply that are identifiable in a system of equations, the simultaneous estimation approach should

[2] These two assertions are equivalent to the Kuhn-Tucker conditions of the quadratic programming formulation of spatial equilibrium. See [12].

[3] In practice, because of the error in measurement and imperfect competition, the sample data do not necessarily fulfill this condition, especially in the supply-demand adjustment over space for short periods of time. If we adopt this assumption, we may redefine the per unit loss function as

$$(5a) \quad r_{ij}^* = (t_{ij} + c_{ij}) - (p_j - p_i) + d_{ij}$$

where c_{ij} denotes opportunity cost defined as the possible profit that the producers would earn if they engaged in other economic activities with the same effort as shipping one unit of the commodity from i to j, and d_{ij} is the possible error in measuring prices. Thus, c_{ij} is due to imperfect competition and d_{ij} to errors of observation which may have zero expectation. The equilibrium condition is then

$$(6a) \quad r_{ij}^* x_{ij} = 0.$$

[4] In augmented model there may be n^2 equations for each set of (5) and (6) including r_{ii}'s, and the demand price p_i may be different from supply price (say p^i); thus there will be $4n+2n^2$ equations and $4n+2n^2$ variables, and the system is still complete. An abbreviated model may be obtained if equations (3) and (4) are substituted into equations (1) and (2). In this case, there will be only $2n^2$ equations and $2n^2$ variables, and the model is still complete. See Table 1.

Table 1. The spatial simplex tableau for the three-market model

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Basis	B_0	X_{12}	X_{13}	X_{21}	X_{23}	X_{31}	X_{32}	X_{11}	X_{22}	X_{33}	p_1	p_2	p_3	r_{12}	r_{13}	r_{21}	r_{23}	r_{31}	r_{32}
1	13	t_{12}										-1	1		1					
2	14	t_{13}										-1		1		1				
3	15	t_{21}										1	-1				1			
4	16	t_{23}											-1	1				1		
5	17	t_{31}										1		-1					1	
6	18	t_{32}											1	-1						1
7	0	$D_1(z)$			1		1		1			$-\alpha_1$								
8	0	$D_2(z)$	1					1		1			$-\alpha_2$							
9	0	$D_3(z)$		1		1					1			$-\alpha_3$						
10	0	$S_1(z)$	1	1					1			$-\beta_1$								
11	0	$S_2(z)$			1	1				1			$-\beta_2$							
12	0	$S_3(z)$					1	1			1			$-\beta_3$						
13–18			$x_{ij}=0$ if $r_{ij}>0$						$x_{ii}\geq 0$			$p_i \geq 0$			$r_{ij}=0$ if $x_{ij}>0$					

be used. If the system of equations is large, with many markets or products involved, and if time series data available are rather short, principal components of predetermined variables may be used as instrumental variables [9].

Spatial equilibrium and static analysis

In the model specified above, there are $2n+2n^2$ equations in which $n(n-1)$ equations are bilinear (equation (6)). There will be $2^{n(n-1)}$ solutions satisfying equations (1) through (6) including any possible real and complex number solutions. The complex number solution is not possible because the bilinear equations are homogeneous and may be factorized into two linear equations. However, among $2^{n(n-1)}$ real solutions, most of the basic solutions in which some variable or variables may take negative values are not economically feasible solutions. Thus, to obtain an economically meaningful equilibrium solution, nonnegativity restrictions must be imposed on all jointly dependent variables. As a consequence, questions about existence and uniqueness of spatial equilibrium arise. However in the light of theorems of Arrow and Debreu [1], Debreu [3], and McKenzie [10], we may tentatively conclude that if the economy has only one equilibrium, the system of equations specified above for that economy will have a unique nonnegative solution.

To solve for the jointly determined variables, we may simplify the model by equating equations (1) and (3), and (2) and (4) to reduce the number of variables and equations to obtain

$$(7) \quad \sum_{i=1}^{n} x_{ij} - \alpha_j p_j = \sum_{m=0}^{k} a_{jm} z_m + u_j \qquad \text{all } j$$

$$(8) \quad \sum_{j=1}^{n} x_{ij} - \beta_i p_i = \sum_{m=0}^{k} b_{im} z_m + v_i \qquad \text{all } i$$

Now only equations (7) and (8) together with equations (5) and (6) must be solved for nonnegative shipments x_{ij}, prices p_i and "profit margins" r_{ij}. An example of a system of equations is given in Table 1, in which $D_i(z)$ and $S_i(z)$ represent functions of predetermined variables or, respectively, the right hand side of (7) and (8) except disturbances. The procedure for obtaining a solution is equivalent to Wolfe's quadratic programming algorithm [15], which was also adopted by Takayama and Judge [12]. Thus, solving the 2nd order simultaneous equations (1) through (6) is equivalent to solving the Takayama-Judge quadratic programming problem,[5] and the existence and uniqueness of a spatial equilibrium are further confirmed.

When the equilibrium solution is obtained, those variables taking on a zero value in (6) may be deleted and the set of reduced form equations obtained. It is important to know that the reduced form equations are known only when direction of commodity flows are known; that is, those x_{ij}'s which are zero are known and may be deleted. However, we do not necessarily know the precise quantity of flow. Direction of flow is primarily determined by the magnitude of exogenous variables, t_{ij}'s and z_i's. Within a certain range of exogenous variables, although the quantity of shipment may be different, direction of shipment may remain unchanged. Therefore, coefficients of reduced form equations are rather stable in the neighborhood of equilibrium.[6] It is reasonable to study the

[5] The exactly identical simplex tableau as Takayama-Judge's may be obtained if demand and supply prices are independently defined. In this paper we prefer to have the simplex tableau written in the most compact form, yet containing the necessary information.

[6] Reduced form coefficients are "locally stable" with respect to an infinitesimal change of an exogenous variable

effect of infinitesimally small changes in t_{ij} or z_i on x_{ij}, r_{ij}, and p_i by taking the partial derivative of say p_i with respect to z_j from reduced form equations.

Empirical Analysis for Broilers

A model for broilers

Alternative relationships among variables were formulated to estimate supply functions of broilers in the Northeast, the South, and the rest of the United States.[7] In most cases, estimated price coefficients are negative and not statistically significant from zero. At the national level, it has been shown that change of broiler supply from the preceding year is positively related to lagged profitability [13, p. 10]. Thus, current supply of broilers is related to the preceding year's supply and profitability. If spatial flow of broilers is also considered, lagged supply in other regions may also affect current regional supply. In the final analysis, therefore, regional supply is hypothesized as a function of lagged national supply Q_{t-1} and lagged regional profitability R_{it-1}:

$$(9) \quad S_{it} = b_{i0} + b_{i1}Q_{t-1} + b_{i2}R_{i\ t-1} + v_{it}$$

where v_{it} is the disturbance term. Lagged regional profitability in this study is defined as the lagged broiler price (p_{it-1}) minus the major cost of production. The major cost is calculated as regional lagged feed price (p_{fit-1}) multiplied by lagged feed per pound of broilers (F_{it-1}).[8] In equation form, the profitability relation is

$$(10) \qquad R_{i\ t-1} = p_{i\ t-1} - F_{i\ t-1}\ p_{fi\ t-1}$$

It implies that producers will respond to profitability but are indifferent as to whether the increase in profitability is due to an increase in broiler price or decrease in feed price, or improvement in technology.

On the demand side, aggregate quantity demanded in each region is postulated as a linear function of current broiler price p_{it} and current total national disposable income y_t:

$$(11) \qquad D_{it} = a_{i0} + \alpha_i p_{it} + a_{i1}y_t + u_{it}$$

where u_{it} is the disturbance term.[9]

The definitional equations include six equations of the distribution activities (3) and (4), and six equations of the per unit loss (5). The six equilibrium conditions are defined by equation (6). Thus there are in total 18 equations, in which 12 equations are linear and six equations are bilinear.

The estimated structural equations and spatial equilibrium

The two-stage least squares method is used in estimating the parameters. The results, given in Table 2, show that the lagged quantity is a significant variable in explaining current supply at the 1 percent significance level. Profitability is significant only in the South at the 1 percent significance level. All the F-tests show significant association between regressand and regressors[10] at the 1 percent significance level. In the demand equations variables are highly associated, coefficients are significant, and signs are compatible with theory.

The equilibrium solution[11] for each year is solved when all predetermined variables are given by numerical values. The solutions are consistent with the fact that in 1956 the northeast region was self-sufficient with essentially

but this does not imply being "globally stable." If the change in z_i or t_{ij} is not infinitesimally small, it is quite possible that the direction of commodity flow may change; and a new equilibrium must be relocated to determine the flow pattern and the new set of reduced form equations associated with it.

[7] The northeast region consists of New England, Mid-Atlantic, and Virginia. The southern region includes North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Arkansas. Hereafter, the North will be region one; the South, two; and the rest of the United States, three.

[8] The cost analysis would be in detail if other costs, such as chick costs, medication and grower payments, etc., are included. However, from the regional cost advantage point of view, only relative profitability between regions is necessary. Hence, only feed costs are included in the regional profitability function. Other components of total costs vary between regions in almost the same manner as do feed costs. Feed costs represent over 60 percent of the total cost of a finished bird and are approximately 60 percent of total costs even after adjusting feed prices for integrated operations.

[9] Regional disposable income was used in the initial analysis and then deleted in the final analysis because (1) regional disposable income is highly correlated with national disposable income, and alternative results are very close; and (2) if the regional disposable income is used, the reduced form equations suffer from multicollinearity and are very expensive in terms of degrees of freedom.

[10] The terms regressand and regressors are used instead of conventional dependent and independent or explanatory variables because (1) our regressors are not necessarily independent but are jointly dependent, and (2) some of the regressors in the second stage estimation are the "calculated" value of jointly dependent variables. For the distinctions among terms, see Goldberger [5, pp. 213–215].

[11] Equilibrium solutions are computed merely for the purpose of forecasting, and no normative connotation is attached [11, p. 8]. Deviations of the data from equilibrium solutions are only an indication of the goodness-of-fit and not a normative critique of the competitive markets.

Table 2. Estimated regional supply and demand relations for broilers (1956-1967) by two-stage least squares

Region	Supply or demand	Constant term	National disposable income	Lagged national supply	Regional farm price	Lagged regional profit-ability	R^2	Computed F statistic[a]
		millions of pounds	*billions of dollars*	*millions of pounds*	*cents per pound*			
North	S_1	536.1950		0.1066 (0.0202)[b]		7.1109 (7.0915)	0.8772	32.134
South	S_2	−1436.6000		0.8879 (0.0475)		50.9301 (17.4122)	0.9879	367.7505
Rest of the United States	S_3	523.4655		0.0909 (0.0223)		6.1178 (8.2029)	0.8614	27.9649
North	D_1	902.8352	0.00312356 (0.00030828)		−31.7407 (10.2671)		0.9781	201.4295
South	D_2	288.2400	0.00173915 (0.00015478)		−13.5484 (4.3070)		0.9804	225.5702
Rest of the United States	D_3	1197.217	0.006235600 (0.00079306)		−44.9175 (22.2277)		0.9649	123.6707

[a] The value in the F-table for degrees of freedom (2,9) at the 1 percent significance level is 8.02.
[b] Figures in parentheses are standard errors.

no receipts of broilers from the southern states. In 1957 the northeast region became a deficit area and in 1967 approximately 30 percent of the broilers consumed came from the southern states. Comparing the predicted equilibrium and actually measured prices, we find that differences are in general small. The equilibrium solution for 1967 is forecast and given in Table 3.

Table 3. The equilibrium solutions for broiler markets in 1967[a]

Predetermined variables	Jointly determined variables
$Q_{t-1}=6191$ million lbs.	$p_1=20.61$¢ per lb.
$y_t=536.815$ billion dollars	$p_2=18.96$¢ per lb.
$t_{12}=1.65$¢ per lb.	$p_3=20.26$¢ per lb.
$t_{21}=1.65$¢ per lb.	$X_{11}=1{,}217.85$ million lbs.
$t_{13}=1.51$¢ per lb.	$X_{22}=964.98$ million lbs.
$t_{31}=1.51$¢ per lb.	$X_{33}=1{,}114.92$ million lbs.
$t_{23}=1.30$¢ per lb.	$X_{21}=707.63$ million lbs.
$t_{32}=1.30$¢ per lb.	$X_{23}=2{,}519.69$ million lbs.
$R_{1\,t-1}=4.56$¢ per lb.	$X_{31}=0$ million lbs.
$R_{2\,t-1}=2.59$¢ per lb.	$X_{32}=0$ million lbs.
$R_{3\,t-1}=4.69$¢ per lb.	$X_{12}=0$ million lbs.
	$X_{13}=0$ million lbs.
	$r_{12}=3.30$¢ per lb.
	$r_{13}=1.86$¢ per lb.
	$r_{31}=1.16$¢ per lb.
	$r_{32}=2.60$¢ per lb.
	$r_{21}=0$ per lb.
	$r_{23}=0$ per lb.

[a] The representative points for three regions are New York City; Gainesville, Georgia; and Chicago.

The direct effect and the spatial equilibrium multipliers

The conventional way to study consumers' behavior is to determine price and income elasticities from demand equations. The slope of the demand equation indicates only a direct effect within a single sector of the economy, especially when price or quantity is simultaneously determined with other sectors. Thus, elasticities computed from a single structural equation may be considered as "partial" elasticities.

Ceteris paribus, partial price and income elasticities are evaluated at equilibrium prices and quantities.[12] The results, given in Table 4, indicate that elasticities are changing from time to time because of simultaneous shifting of demand and supply.[13]

Coefficients of the linear reduced form equa-

[12] In most of the empirical studies the elasticities are evaluated at the average price. Since the demand and supply are shifting over time, it is more appropriate to evaluate them at equilibrium prices and quantities.

[13] The elasticities in 1956 may be compared with the average monthly elasticities of the period 1953–1963 given by Farris and Darley [4]. In making comparison, however, one should bear in mind that their elasticities were converted from flexibilities computed at mean prices and quantities for 1953–1963. In addition, all data were on a per capita basis, and estimates were obtained by single equation ordinary least squares.

Table 4. Estimated "partial" price and income elasticities for broilers at farm level, by regions, 1956-1967

Year	Price elasticities			Income elasticities		
	North	South	Rest of the United States	North	South	Rest of the United States
1956	−1.03	−0.94	−0.81	1.02	1.24	1.09
1957	−0.98	−0.82	−0.71	1.02	1.18	1.05
1958	−0.74	−0.62	−0.56	0.91	1.06	0.97
1959	−0.60	−0.49	−0.45	0.86	1.00	0.92
1960	−0.53	−0.43	−0.40	0.83	0.97	0.90
1961	−0.48	−0.39	−0.36	0.82	0.95	0.89
1962	−0.44	−0.35	−0.33	0.82	0.94	0.88
1963	−0.47	−0.38	−0.35	0.85	0.97	0.91
1964	−0.44	−0.36	−0.33	0.86	0.98	0.92
1965	−0.49	−0.39	−0.36	0.92	1.02	0.96
1966	−0.39	−0.31	−0.29	0.89	0.98	0.93
1967	−0.34	−0.27	−0.25	0.87	0.97	0.92

tions, which indicate the "total" effect of a change in predetermined variables on current endogenous variables after taking account of interdependencies among current endogenous variables, may be called "multipliers." Since the equilibrium solution pattern of 1956 is different from the other years in the series, the impact multipliers [5, pp. 374–375] are computed for the shipping pattern of the period 1957 through 1967 and are given in Table 5.

Since supply equations do not depend on current prices, the model may be considered a recursive system. For example, the data in Table 5 indicate that if profitability in the northeast region is increased by one cent with other predetermined variables being constant, supply in the northeast region will increase by 7.11 million pounds. However, this increase in supply in the Northeast will cause a decrease in supply price of 0.08 cents per pound. The flow of commodities will result in a decreased shipment of broilers from the South to the North by 4.61 million pounds. The South will increase shipments to the rest of the nation by 3.54 million pounds and increase by 1.07 million pounds the quantity of broilers sold in the South. As a result, the South and the rest of the nation will decrease the price by 0.08 cents to stimulate more consumption. The consumption in each region will increase by 2.50, 1.07, and 3.54 million pounds for the North, the South, and the rest of the United States, respectively.

"Total" elasticities, which take into account the interdependence of current endogenous variables, are evaluated at equilibrium in 1967 (Table 6). The results indicate that elasticities are small.

The effect of change in feed price on broiler production and derived demand of feed

The effect of change in feed price on broiler production may be evaluated by

$$\frac{\partial S_{it}}{\partial p_{fi\,t-1}} = \frac{\partial S_{it}}{\partial R_{i\,t-1}} \cdot \frac{\partial R_{i\,t-1}}{\partial p_{fi\,t-1}} = -\frac{\partial S_{it}}{\partial R_{i\,t-1}} \cdot F_{i\,t-1} \tag{12}$$

With 1967 technology, if feed price decreases by 1 cent per pound, production in the North will increase 24.82 million pounds; production in the South will increase 117.75 million pounds; in the rest of the nation, by 21.35 million pounds. The increase in feed demanded would be 86.62, 620.33, and 74.52 million pounds for the North, the South, and the rest of the United States, respectively. The elasticities of supply of broilers and derived demand of feed with respect to feed price are identical: −.10, −.21, and −.09 for the North, the South, and the rest of the United States, respectively.

Table 5. Spatial equilibrium multipliers for broilers, 1957-1967

Total effect of / on	Lagged profitability			Lagged national supply	National disposable income	Transportation costs			Constant term
	North	South	West			South to North	South to rest of United States	North to rest of United States	
P_1	−0.0789	−0.5653	−0.0679	−0.0120	0.0001232	0.6481	−0.4979	0	30.6941
P_2	−0.0789	−0.5653	−0.0679	−0.0120	0.0001232	−0.3519	−0.4979	0	30.6941
P_3	−0.0789	−0.5653	−0.0679	−0.0120	0.0001232	−0.3519	0.5021	0	30.6941
X_{11}	7.1109	0	0	0.1066	0	0	0	0	536.1950
X_{21}	−4.6086	17.9223	2.1141	0.2754	−0.0007819	−20.572	15.805	0	−606.4448
X_{22}	1.0681	7.6497	0.9189	0.1630	0.0000722	4.7672	6.7463	0	−127.0948
X_{23}	3.5405	25.3581	−3.0717	0.4495	0.0007097	15.805	−22.551	0	−703.0574
X_{33}	0	0	6.1178	0.0909	0	0	0	0	523.4655
S_1	7.1109	0	0	0.1066	0	0	0	0	536.1950
S_2	0	50.9301	0	0.8879	0	0	0	0	−1436.6000
S_3	0	0	6.1178	0.0909	0	0	0	0	523.4655
D_1	2.5023	17.9223	2.1141	0.3820	−0.0007819	−20.572	15.805	0	−70.2498
D_2	1.0681	7.6497	0.8189	0.1630	0.0000722	4.7672	6.7463	0	−127.0978
D_3	3.5405	25.3581	3.0464	0.5404	0.0007097	15.805	−22.551	0	−179.5919

Table 6. "Total" elasticities for broilers, 1967

Elasticity of \ With respect to	Lagged profitability			Lagged national supply	National disposable income	Transportation costs	
	North	South	Rest of the United States			South to North	South to Rest of United States
P_1	−.02	−.07	−.02	−.36	.00	.04	−.04
P_2	−.02	−.08	−.02	−.39	.00	−.02	−.00
P_3	−.02	−.07	−.02	−.37	.00	−.02	.00
X_{11}	.03	0	0	.05	0	0	0
X_{21}	−.03	.07	.01	.24	.00	−.04	.04
X_{22}	.01	.02	.00	.10	.00	.01	.01
X_{23}	.01	.03	−.01	.11	.00	.01	−.01
X_{33}	0	0	.03	.50	0	0	0
S_1	.03	0	0	.05	0	0	0
S_2	0	.03	0	.13	0	0	0
S_3	0	0	.03	.50	0	0	0
D_1	.01	.02	.01	.12	.00	.01	.01
D_2	.01	.02	.00	.10	.00	.01	.01
D_3	.00	.02	.00	.09	.00	.01	−.01

Conclusions

Spatially competitive markets may be positively analyzed. With a certain level of statistical significance, the simultaneously estimated demandand supply functions along with equilibrium conditions describe how interregional competition has developed and therefore provides a basis for forecasting, if past structure prevails in the future. In addition the model provides equilibrium multipliers which answer questions arising from comparative static analysis.

The estimated demand functions for broiler markets are compatible with consumer behavior. Income slowly stimulates broiler consumption in each region. Supply is largely predetermined by the previous year's production with an insignificant amount of adjustment to the previous year's profitability.

The simultaneous shifting of demand and supply has a tendency to decrease equilibrium prices and increase broiler production. In 1967 interregional shipment of broilers equalized farm prices at approximately 19 cents per pound of ready-to-cook broilers in the South, with prices in other regions higher by transportation costs.

Spatial equilibrium multipliers indicate that insignificant increases in broiler prices result from increasing consumer income. As lagged profitability increases, broiler prices will decrease. The negative effects of lagged national supply on prices has important implications for broiler supply control.

The forecasted equilibrium solutions are quite close to the observed values despite the fact that the study is highly aggregated over time and space and does not take into account seasonality and normative aspects of the production process. However, it does give a positive picture of the existing and changing structure of interregional competition for broilers.

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From Hedging to Pure Speculation: A Micro Model of Optimal Futures and Cash Market Positions*

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A theoretical model of optimal firm decisions in cash and futures markets that includes both primary product producers and marketing firms is presented. The generalized model of production and marketing decisions under risk is applied to both short and long hedging and speculation. Hedging and speculation are given precise definitions. Speculation exists when a firm's futures position exceeds the 100 percent hedging level or when it does not provide hedging possibilities in conjunction with the cash market position. Comparisons between hedging on futures markets and forward contracting are made. Live beef futures are used to show how transformation costs for nonstorable commodities should be treated in the same manner as storage costs for storable commodities.

THE DIFFERENCE between the current cash price for grain and the price for delivery at some future date is interpreted as the market price of storage. When processing is involved, as for soybeans, the spread between spot soybeans and forward soybean products is seen as the market price for the required storage and processing services [6]. For cattle the spread between cash prices for feeders and feed and future prices for fed cattle represents the market price for feedlot services [5]. In each instance, a product transformation (i.e., storage and/or processing services) is involved, and the price of these transformation services is the linkage leading to the simultaneous determination of cash and futures prices. Existing theories of futures trading in relationship to cash markets have been incomplete when applied to the individual decision maker, however. In this paper we try to clarify the role of futures markets in production and marketing decisions under risk. We also attempt to provide a more general theoretical model than is now available for optimal firm decisions in cash and futures markets by considering both primary product producers and marketing agencies.

McKinnon [4] has developed a theory of futures utilization by primary producers as a hedge against *production* and *cash price risks*. His derivation of optimal hedges follow from the assumption that producers wish to minimize the variance of income. He answers the following question: Given a specified level of input X, what is the optimal hedge? Stein [8] outlined a theory explaining the allocation between hedged and unhedged holding of stocks. Given a utility map relating expected returns and risk, the optimal combination of hedged to unhedged stocks can be found. The optimal hedging proportion provides the maximum attainable level of utility for the inventory holder.

Johnson's reformulation of the theory of hedging [3] suggested that hedging and speculative activities are often combined in the actions of a decision maker.

In none of these articles, however, have the arguments exhausted all of the market alternatives; i.e., a more generalized theory applicable to both short and long hedging and speculation by producers and marketing firms is needed. We have incorporated much of the existing theory in this attempt to develop a more general micro model of optimal behavior in cash and future markets.[1]

We have made use of live beef futures for expository purposes [1, 2, 7]. The role of storage is less meaningful to beef futures trading than product transformation. Corn can be stored from one period to another, but feeder cattle are fattened and then slaughtered with only very limited storage possibilities. In both instances, however, a service has been performed that yields a final output different from the initial input. Transformation cost, therefore,

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[1] This article could be expressed in a framework of portfolio theory, where portfolio analysis is generally viewed as a decision mechanism for selecting assets with uncertain yields. Define a vector $z=(x, x_f)$, where x and x_f are coordinates of possible cash and futures markets and p_z is a vector of market returns that are unknown at the time of portfolio selection. Portfolio theory then establishes that a demand for z appears as $z_D=z(p_z, \mu_z, \sigma_z, \kappa)$, where the vectors μ_z = mean, σ_z = var-cov matrix and κ is some constant. We have limited our selection theory to one cash and one futures market, yet this restriction will enable us to show precisely the optimal market positions that would not be immediately evident under the general portfolio approach.

should be treated in the same manner as storage cost; that is, both are service costs incurred between time periods t and $t+k$ [5].

Our model of individual decision making will show explicitly: (1) the alternative futures and cash market positions that can be established by producers and marketing firms; (2) the role of income, cost, risk, and expectations in the decision process; (3) optimal positions in the futures and cash markets; and (4) hedging and speculative positions in futures and cash markets. Part I presents the necessary assumptions, conditions, and theoretical framework; part II, the determination of optimal levels of the choice variables. A final section contains the conclusions and implications of the model, together, with some comparisons between hedging on futures markets and forward contracting for the individual decision maker.

I

Decision-making framework

Assume a finite number of decision makers operating in a purely competitive environment. Each market participant has a given occupation and has made the necessary capital investment for functioning in the cash market. The decision maker may be a feedlot operator who has previously made all necessary capital investments in feedlot facilities. His decision process then consists of making the appropriate decisions in period t for the optimal number of feeder cattle to purchase and the optimal futures position. This position in futures would be expected to be terminated k periods from t, where k is the time required for transformation of feeders into slaughter animals. In essence, the present decision theory will encompass only the short run, since the transformation (feedlot) capacity is taken as fixed.

Income and cost considerations

Each market participant can establish one or any combination of market positions in period t where X and X_f are the two choice variables representing *quantities* in the cash and futures markets. X is measured in *live animal units* of given *weight* and *quality*, and X_f is expressed in equivalent live animal units. Thus, the market positions can be summarized:

$X_f>0$ — a short position in futures contracts from period t to $t+k$ for contracts maturing in period $t+n$, $k\leq n$ (the decision maker sells beef futures during period t);

$X_f<0$ — a long position in futures contracts from period t to $t+k$ for contracts maturing in period $t+n$, $k\leq n$ (the decision maker buys beef futures during period t);

$X>0$ — cash market purchases in period t for commodity requiring k periods for product transformation (the number of feeder cattle purchased and placed in feedlot in period t);

$X<0$ — cash market quantities contracted in period t for delivery in period $t+k$, or cash market purchases *planned* in period t for period $t+k$ (the number of slaughter steers sold for deferred delivery or anticipated purchases of slaughter steers at $t+k$).

Market prices are expressed as:

P_t = cash price per unit of X (where $X\geq 0$) in period t (price of feeder cattle per animal in period t);

P_{t+k} = cash price per unit of *transformed* X in period $t+k$ (price of slaughter steers per animal in period $t+k$);

P_t' = cash market contracting price per unit of X (where $X<0$) in period t for delivery in period $t+k$;

F_t = futures price per unit of X_f in period t for contract maturing in period $t+n$;

F_{t+k} = futures price per unit of X_f in period $t+k$ for contract maturing in period $t+n$, $k\leq n$.

Each decision maker also incurs costs from his participation in the cash and futures markets. Define:

C = average cost of transformation and marketing of X;

C_f = average cost of futures position in X_f.

Prices P_{t+k} and F_{t+k} are unknown at period t; hence, they are assumed to be random variables where the mean and variance is known. The cash position may be either $X\geq 0$ or $X<0$; similarly, the futures position is either $X_f\geq 0$ or $X_f<0$. The absolute values of X and X_f indicate the magnitude of a market position while the signs of X and X_f identify the type of position.

Expected net income equations can now be defined:

$$E\pi(X\geq 0,\ X_f \gtrless 0)$$

$$= XE[P_{t+k}-P_t]-X_fE[F_{t+k}-F_t] - |X|C - |X_f|C_f \tag{1}$$

$$E\pi'(X < 0, X_f \gtreqless 0)$$
$$(2) \quad = XE[P_{t+k} - P_t'] - X_f E[F_{t+k} - F_t] - |X| C - |X_f| C_f$$

Equation (1) represents a decision maker's expected net income with both cash ($X \geq 0$) and futures ($X_f \gtreqless 0$) market positions. Equation (2) applies when forward contracting and anticipated purchases in the cash market ($X<0$) exist in conjunction with a futures position ($X_f \gtreqless 0$).[2] In either equation the decision maker cannot be both short ($X_f \geq 0$) and long ($X_f<0$) at the same time.

Decision-making risk

In this article, risk to the decision maker results from variations in realized net income when price expectations do not materialize. Each individual is assumed to be a risk averter in the sense that he will choose those market positions that minimize his risk for a given expected net income. Risk is then defined as the variance of net income. Given the combinations of expected net income and risk and the shape of the decision maker's preference function relating risk to expected net income, the format for determination of optimal market positions is set.[3]

II

Optimal market position for the short hedger

We assume that a market participant chooses his positions in the cash and futures markets at period t based on his price expectations. The goal of the decision maker is to maximize expected net income; however, since expected prices may not materialize, risk prevails and must be considered when establishing cash and futures positions. Thus, we use a trade-off approach between expected net income and risk as elements in the decision maker's utility function leading to the simultaneous determination of optimal positions in the cash and futures markets.

If the variance of net income is taken as a measure of risk, a theoretical risk function for net income (equation (1)) can be written:

$$(3) \quad \mathrm{Var}\,(\pi) = X^2\sigma_p^2 + X_f^2\sigma_f^2 - 2XX_f\rho\sigma_p\sigma_f$$

where

$$\sigma_p^2 = \mathrm{Var}\,(P_{t+k} - P_t) = \mathrm{Var}\,(P_{t+k} \mid P_t)$$
$$\sigma_f^2 = \mathrm{Var}\,(F_{t+k} - F_t) = \mathrm{Var}\,(F_{t+k} \mid F_t)$$
$$\rho = \sigma_{pf}/\sigma_p\sigma_f$$
$$= \text{correlation between } (P_{t+k} - P_t) \text{ and } (F_{t+k} - F_t).$$

This function assumes that σ_p^2, σ_f^2, and ρ are known and constant for the given decision maker. The greater (smaller) the positive correlation between cash and futures prices, the smaller (larger) risk will be. Risk also decreases as the variance of cash and futures prices decrease.[4]

This equation holds for any decision maker who establishes a futures position against a current position in the cash market ($X>0$). Equation (3) can be represented in an iso-variance map where each iso-variance curve includes all combination of cash and futures positions yielding a constant risk value. Curve V_0 in Figure 1a, for example, gives the alternative values of X and X_f necessary for (3) to sum to V_0.

In Figure 1a, the horizontal axis shows the cash position (X), and the vertical axis indicates the futures (X_f). Market positions can be purely speculative, purely hedging, or some combination of the two. All commitments established on the vertical axis are purely short speculative positions; those on the horizontal axis involve no futures position. Any point lying between the cash position axis and the 100 percent hedging line (the 45° line) repre-

[2] It is assumed that all costs (C, C_f) are linearly related to the quantity variables (X, X_f). Total revenues and cost vary in equations (1) and (2) according to the type of position. If $X>0$ and $X_f>0$, total revenue is $XP_{t+k}+X_fF_t$; but if $X_f<0$, it is $XP_{t+k}-X_fF_{t+k}$. Similarly, when $X<0$ and $X_f<0$, total revenue is $-XP_t'-X_fF_{t+k}$; but if $X_f>0$, it is $-XP_t'+X_fF_t$.

[3] McKinnon states that output at harvest time can be viewed at planting time as a random variable [5, p. 846]. This would imply that at period t the transformed X of period $t+k$ would be viewed as a random variable. Transformation risk in our framework may exist through changes in quality and weights of the initial cash stock (feeder cattle). We have assumed that quality and weight risk are reflected directly in the prices received. Price risks then absorb differences due to variations in quality and weights. We have assumed that remaining transformation risks are negligible; i.e., the same number of X units of input in period t yields the equivalent number of output units in $t+k$.

Transformation risk varies with the commodity considered, hence one extension of our framework would be to introduce a completely random transformation effect.

[4] Variances of (3) are defined to be conditional probabilities only if the prices of period t and $t+k$ are not independent. See [1, 3, 4, and 9] for useful discussions of risk-measurement criteria.

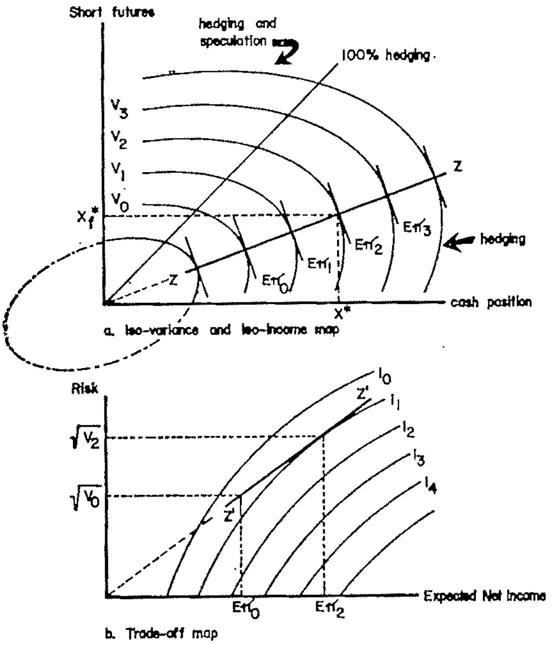

Figure 1. Risk, income, and trade-off maps when hedging is potentially profitable

sents a cash position with a short hedge, and this hedge is less than the cash position. All points lying on the 45° line represent 100 percent hedges, and points to left of this line correspond to a combination of hedging and speculation.

Expected net income equations (iso-net incomes) can be drawn over the iso-variance map as shown in Figure 1a. In this quadrant, $X \geq 0$ and $X_f \geq 0$ and the position of each iso-net income line depends on the magnitudes of X and X_f. For example, line $E\pi_0$ defines combinations of X and X_f (given $X \geq 0$ and $X_f \geq 0$) necessary for equation (1) to sum to $E\pi_0$.

The decision maker's iso-variance map is assumed constant, but his iso-net income map will vary according to his price expectations. Specifically, the slope of $E\pi_i$ will change according to the expectations in equation (1). If the decision maker's expectations are such that $\{E[F_t - F_{t+k}] - C_f\} = 0$, then the expected net income is independent of the amount of futures. In this instance, iso-net income lines would be drawn parallel to the vertical axis in Figure 1a. Probably a more realistic alternative is when the expected net returns from futures activities are greater than zero; i.e., $\{E[F_t - F_{t+k}] - C_f\} > 0$. Here expected net income is not independent of the hedging level; hence, hedging may be used, not only for its *risk-shifting capacity*, but also for its *profit potential*. The iso-net income lines may have a slope like that shown in Figure 1a. The greater (smaller) the expected futures return, the smaller (larger) will be the slope of each iso-net income line.

A decision maker will for each iso-net income choose a level of short futures that will minimize his iso-variance. Graphically, this minimum point is where an iso-net income ($E\pi_i$) is tangent to an iso-variance curve (V_i).

The combination of all possible tangency points gives the line ZZ of Figure 1a, and this tangency locus ***must be a linear*** projection from the origin of the iso-variance map since the iso-variance function used is an ellipse. All coordinates of ZZ can be plotted on a trade-off map between expected net income and risk, thus giving the locus $Z'Z'$ of Figure 1b. Any combination along $Z'Z'$ can be chosen, but the rational decision maker maximizes his utility under the constrained conditions by selecting the point that places him on his highest indifference curve. In the example from Figures 1a and 1b, $E\pi_2$ and V_2 give the constrained maximum utility. Referring back to the iso-variance map, the combination of $E\pi_2$ and V_2 indicates that X_f^* is the optimal short hedge and that X^* is the optimal cash position. Optimization has resulted in a futures position for which the cash market position was not completely hedged. If a 100 percent hedging rule were applied, the decision maker either would have to accept a higher level of risk to maintain the same expected income or reduce his output and expected income to maintain the same level of risk.

In Figure 1a the decision maker establishes a short hedge position at a higher level than if his expected net income were independent of hedging. Indeed, price expectations may be such that the decision maker chooses his optimal position to the left of the 100 percent hedging line (e.g., the tangency locus ZZ rotated counterclockwise). The futures position is then a mixture of hedging and speculation. If this should happen, and the futures position is limited to 100 percent hedging, the firm would find it necessary to raise output to maintain its expected income and risk levels. A smaller increase would be needed to keep risk at the same level, but a larger increment in output as well as a higher level of risk would be required to maintain expected income. If output were held constant, risk would decrease, but at the cost of a reduction in expected net income.

Determination of the optimal market position for the long hedger

A long hedge (buying futures) can occur only if a short cash position has been assumed in period t. The market participant has established some deferred-delivery contractual agreement at price P_t' in period t for delivery in $t+k$ and he expects to purchase the commodity in period $t+k$. Evaluation of deferred-delivery contracting and long hedging applies to those market participants not directly involved in the production process at the initial period t.

Equation (2) expresses the relevant net income for these situations ($X<0$). For example, P_t' may be the contracted price of live beef to be delivered in period $t+k$. Alternatively, P_t' may represent the contracted value of an animal unit after processing. In both instances, the cash selling price of output has been established but the purchase price is subject to variations. Income equation (2), along with the appropriate risk function, can be used to determine the optimal market positions. Only the cash and futures prices of period $t+k$ are unknown in equation (2); therefore, the variance of (2) can be written as:

$$(4)\quad \mathrm{Var}\,(\pi') = X^2\sigma_{p'}^2 + X_f^2\sigma_f^2 - 2XX_f\rho'\sigma_{p'}\sigma_f$$

where

$$\sigma_{p'}^2 = \mathrm{Var}\,(P_{t+k} - P_t') = \mathrm{Var}\,(P_{t+k} \mid P_t')^5$$

$$\rho' = \sigma_{p'f}/\sigma_{p'}\sigma_f$$

$$= \text{correlation between } (P_{t+k} - P_t') \text{ and } (F_{t+k} - F_t).$$

The optimal market position follows in the same manner as the procedure for determining cash and short hedging positions. The iso-variance and iso-net income maps are drawn in Figure 2a. The third quadrant is the relevant one since $X<0$ and $X_f<0$ when a deferred-delivery position exists and a long hedge is established. Movements from V_0 to V_4 and from $E\pi_0$ and $E\pi_4$ illustrate increases in iso-variance and iso-net income.

If a decision maker can establish a deferred-delivery sale in period t and anticipates a cash purchase in period $t+k$, then his optimal futures position must be considered simultaneously with his optimal cash market decision. For each expected net income level, the decision maker will minimize his risk; i.e., he will choose that position where the iso-net income is just tangent to an iso-variance. Again, the mechanism for expressing utility for the decision maker is through the trade-off map, Figure 2b. Effects of nonoptimal 100 percent hedging described earlier also exist in this case.

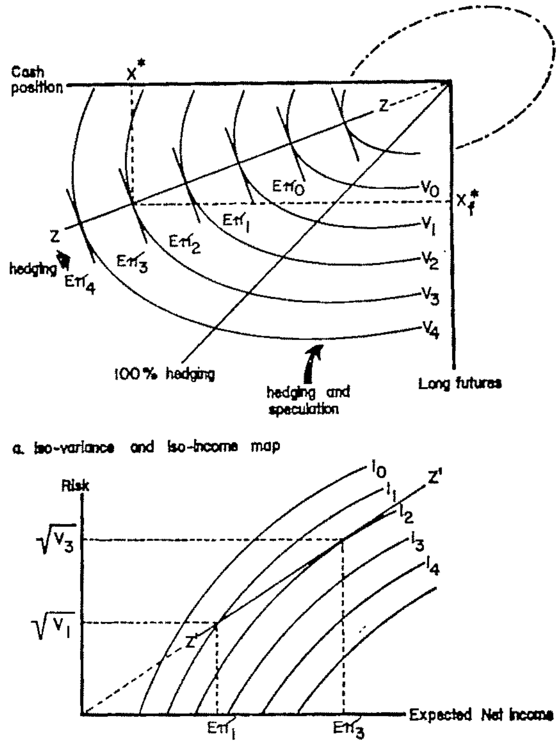

Figure 2. Risk, income, and trade-off maps for long hedges

The case depicted in Figure 2a occurs when the decision maker expects the futures price in $t+k$ to exceed the futures price and average cost of futures transactions in period t. Hence, given that $\{E[F_{t+k}-F_t]-C_f\}>0$, not only can long hedging shift some risk, but also it can increase expected incomes. As this difference approaches zero, the slope of the iso-net income lines approaches infinity; i.e., $E\pi_i$ becomes parallel to the X_f axis. The tangency locus ZZ retains the same meaning as before. All possible combinations of risk and expected net income giving the minimum variance are then plotted over the trade-off map of Figure 2b. The tangency point between $Z'Z'$ and an indifference curve give that combination of risk and expected net income leading to the optimal market position. The coordinates of this tangency ($E\pi_3$, V_3) then indicate the optimal

[5] Variances σ_p^2 and $\sigma_{p'}^2$ are identical if P_{t+k} is independent of P_t and P_t'. In this case, equations (3) and (4) are identical; otherwise, they are not the same.

long futures X_f^* and cash position X^* of Figure 2a. Through the choice of X_f^* and X^*, the decision maker has minimized his risk for a given expected net income and maximized his utility, given all other constraints.

Transition from hedging to pure speculation

Price expectations could be such that futures positions other than a hedge or a hedge combined with speculation should be established. For example, in (1) if $\{E[P_{t+k}-P_t]>C\}$, a cash holding $(X>0)$ should occur. But if expected futures price movements give $\{E[F_t-F_{t+k}]<C_f\}$, the short futures position would *not* be potentially profitable. Similarly, for the contracted cash market position $(X<0)$; if $\{E[F_{t+k}-F_t]<C_f\}$, the long position would *not* be profitable. Hence, when price expectations are such that *holding cash* and *long futures* or *forward cash* and *short futures* exist, the futures position is defined as *pure speculation*. As seen earlier, speculation in the futures market existed when the optimal futures position (short or long) exceeded the 100 percent hedging level. Now we identify a second type of speculation which occurs when the established futures position does not provide hedging possibilities in conjunction with the cash market position.[6]

Figure 3a illustrates a transition from a hedging to a purely speculative futures position. The original short position for the expected net income occurred at the tangency T, thus minimizing the risk for the given iso-net income. As expectations change, the slope of the relevant iso-net income also changes. At some point the decision maker may view the movement of futures prices to be such that $\{E[F_t-F_{t+k}]<C_f\}$. Iso-net income $E\pi_2'$ follows directly from this change in expectation. Although expected futures prices are now such that a loss is expected to occur with a short position, this point will still be chosen (tangency T'). The decision maker will choose a short futures position that minimizes risk, even though a small loss is expected from the short contract (selling futures). The decision maker is said to be paying some premium of minimizing risk.

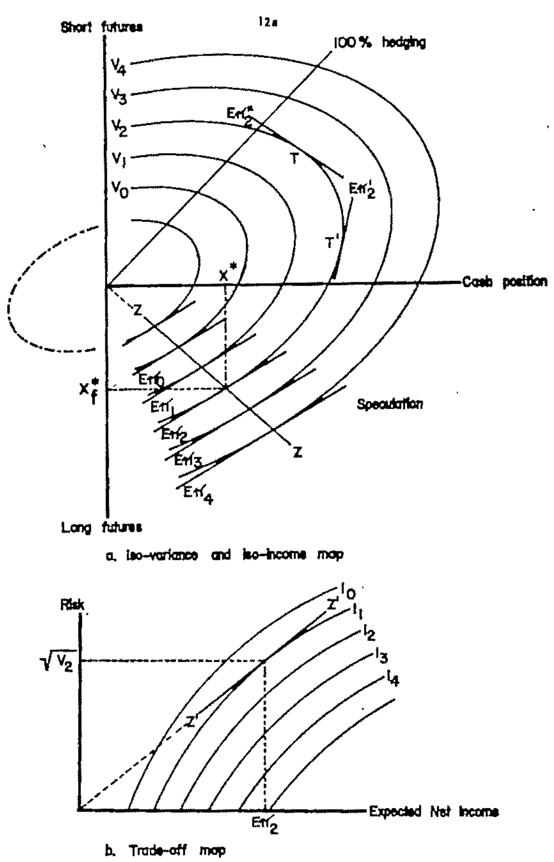

Figure 3. Transition from hedging to pure speculation

As the decision maker's expectations change, his market positions change accordingly. Given that the difference in futures price for period $t+k$ and futures at period t is expected to be large, the decision maker may become a market speculator. This would mean that, in Figure 3a, the iso-net income lines are tangent to the iso-variances only in the lower right quadrant (e.g., tangency locus ZZ rotates clockwise). The highest indifference curve attainable, given the tangency locus of Figure 3b then shows that combination of expected net income and risk $(E\pi_2, V_2)$ leading to the optimal speculative level $X_f^*(X_f<0)$ and cash position $X^*(X>0)$. Any hedging position would reduce utility, given the firm's set of expectations.

A comparable speculative position is that of deferred-delivery contracts and short futures. The decision maker views cash price movements as advantageous for a deferred-delivery position. Yet he also views the expected futures prices to be such that a short position is desirable. In period t futures are sold, and in $t+k$

[6] Both types of speculation are defined for producers and marketing firms with positions in both the cash and futures markets. Another group of market participants, called *speculators*, could be discussed. The optimal position for this group always lies on the vertical axis (short or long futures) of the iso-variance and iso-net income map.

all positions are terminated through offsetting purchases. This position could be illustrated graphically by extending the iso-variances of Figure 2a into the upper left quadrant and then determining the tangency locus, as in Figure 3.

Conclusions and Implications

A set of price expectations, a probability distribution for this set, and a preference function for risk aversion have provided the essential elements for the futures model developed in this article. Within this framework optimal futures and cash market positions were established for producers and marketing agencies. For the primary producer buying feeder cattle, the optimal cash market position was derived simultaneously with the optimal futures position. Processors, dealers, and other marketing agencies can utilize futures as hedges against contracted and anticipated purchases of live animals. The ratio of futures to cash positions could be (a) less than one (less than 100 percent hedging), (b) equal to one (100 percent hedging), or (c) greater than one (hedging and speculation). In addition, cash market participants can be pure speculators when their expectations warrant such positions.

Optimization yielding X^* and X_f^* suggests further considerations not discussed in this paper. The optimal level of X has been established, yet X may take many different forms. Feeder cattle can be purchased at many weight ranges, each requiring different transformation periods. Optimal timing of futures positions have been ignored. For example, we have derived the optimal X_f; yet for beef futures there are six possible contracts that could be used. Also, empirical determination of the assumed density functions often is difficult.

Costs of inputs were assumed given for the market participants who have cash positions in period t. Without instantaneous product transformation, costs may be uncertain. The theory of long hedging could be applied to the uncertainties of input prices for participants who make cash market sales commitments (e.g., the beef feeder). Hedges in both the input and output markets require two distinct futures markets. The processor can hedge inputs through live beef futures, but his outputs would have to be hedged in a futures market for beef carcasses. A beef feeder who completely hedges both his inputs and outputs and has expectations of zero gain or loss in the futures markets could be compared to a feedlot operator feeding cattle on contract. Both sell a service at a fixed price. Both give up the possibility of higher income to avoid risk.

The discussion has been limited to decision making in the cash and futures markets. However, a decision maker could establish many of the hedging positions through forward contracting outside of an organized market. A producer could sell forward directly to a buyer, thus establishing both the selling and buying prices between two decision makers. If both futures markets and forward contracting are feasible, a firm must decide which alternative to use. Most futures markets are characterized by ease of transactions, high liquidity, and security. Forward contracting may not provide these essential elements for successful hedging; hence, direct forward commitments may introduce new risks through an effort to minimize price risks. On the other hand, through forward contracting the decision makers can specify terms most advantageous to the two participating parties, while futures must be traded in specified and rigidly enforced contracts. Such futures contracts are designed to meet a broad spectrum of trading needs; hence, it may not be the optimal contract for any one decision maker. We have not provided formal decision criteria for evaluating these two hedging alternatives. Their similarities and differences have been discussed, but some extreme assumptions would be required to compare them in the model presented [9].

The model extends considerably the analysis of the relation between market output decisions and futures positions. Hedging and speculation are given precise meanings and are logically related to the behavior of both buyers and sellers of a commodity traded on a futures market. However, the implications of the micro model for aggregate market determination of price, output, and profits of buyers and sellers remain to be explored.

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Formulating Beef Rations for Improved Performance Under Environmental Stress*

RAY F. BROKKEN

Beef ration heat increment level (energy lost in ruminant fermentation and nutrient metabolism) relative to net energy has important implications for efficient beef production under heat or chill stress. This paper presents (1) an efficient model for use of the Lofgreen-Garrett net energy system in ration formulation; (2) a model, incorporating the Lofgreen-Garrett net energy system, for varying heat increment relative to net energy in beef ration formulation; and (3) a simplified framework for ascertaining potential animal performance differences caused by differences in relative heat increment under assumed stress conditions. Differences illustrated are substantial.

LOFGREEN AND GARRETT [7, 8] have proposed a system for expressing net energy requirements and feed values for growing and finishing beef cattle. Judging from reports in industry and trade journals, this system is an important innovation in feed evaluation and ration formulation in the fed beef industry.

However, the system is complicated from the standpoint of programming least-cost rations because the total net energy value of any particular ingredient changes with the level of total energy intake. Their system separates requirements for maintenance from that for body weight gain and gives different feed energy values for feed used for these two functions. Feed energy is applied to body weight gain only if the total net energy intake is in excess of that required for maintenance.

This system reflects requirements and feed energy values in environments of *thermal neutrality*. However, in weather conditions where heat stress or chill stress becomes a problem, a third energy fraction, *heat increment*, becomes a factor in determining the rates of substitution among feedstuffs. Heat increment, which occurs concomitantly with net energy, is the difference between metabolizable energy and net energy. In chill stress there is a diversion of energy otherwise available for gain to heat production for maintenance of body temperature. Under heat stress two problems related to the level of heat increment may occur: (1) Any burdensome heat production will be expurgated by diverting energy to this purpose from that which is otherwise useful for body weight gain. (2) Perhaps more significant, because of reduced appetite, feed-intake is reduced. Data indicate that the heat increment relative to net energy for maintenance or to net energy for gain varies widely among feedstuffs [2, 14]. Therefore, a substantial variation in heat increment for any given level of net energy should be obtainable.

The purpose of this paper is to present some concepts and models for formulating beef rations for efficient production under different environmental circumstances.

Following a section giving more detailed definitions and background, a three-equation energy system is presented which incorporates the two equations of the Lofgreen-Garrett net energy system. Two linear programming models are then presented, one for dealing with the Lofgreen-Garrett system and one for obtaining variable levels of heat increment. The differences in heat increment obtainable are illustrated with ration solutions for an animal of a certain weight with two assumed rates of gain. A simplified framework for assessing the differences in animal performance with rations containing different levels of heat increment under assumed environmental conditions is then developed; and finally, an assessment is made of potential economic consequences.

Definitions and Background

Net energy is a measure of the food energy actually used by the animal after energy losses in digestion and metabolism have been subtracted from *gross energy of ingested feed* (GE_i).[1] Since the relative losses incurred in digestion

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[1] Terms in parentheses are standard notation in animal nutrition and are used throughout this paper. For a more thorough discussion and definition of biological energy terms, the reader should consult [2] and [15].

and metabolism vary among feedstuffs, net energy is the most appropriate energy basis for substituting one feedstuff for another in ration formulation in the absence of heat or chill stress.

Losses in digestion and metabolism occur in the form of energy in undigested feed of the feces, *fecal energy* (FE); *urinary energy* (UE); combustible gases from fermentation of the ration, *gaseous products of digestion* (GPD); and heat losses in the form of the heat of fermentation and the heat of nutrient metabolism, which taken together are *heat increment* (HI).

After all of these losses are subtracted, that which is left is *net energy for maintenance* (NE_m), which is expended as heat; and *net energy for production* (NE_p), which is mostly stored in tissues as *net energy of body weight gain* (NE_g) and in wool, feathers, etc., or in products (milk, eggs, fetus).

Obviously, direct determinations of the NE_m and NE_g content of the various feedstuffs is complicated and tedious. For that reason, it is often expedient to use less detailed indicators of relative feed values: (1) *digestible energy* (DE), which is the difference between gross energy and fecal energy, $DE=GE_i-FE$; or (2) *metabolizable energy* (ME), $ME=DE-UE-GPD$ and $ME=HI+NE_m+NE_p$.

Total heat production (HP) is the part of metabolizable energy which is not recoverable in the form of energy stored in the body weight gain. HP includes NE_m, HI, and energy diverted from NE_g to *heat to keep the body warm* (HBW) in chill stress or to *heat to keep the body cool* (HBC) in heat stress. The animal's *critical temperature* occurs when HI is fully utilized and HBW commences. If the level of feeding is so low that no NE_g is available, the HBW comes from body reserves (it loses weight). The point of *hyperthermal rise* occurs when the body temperature commences to rise. HBC is then required to expurgate the burdensome HI. The temperature zone between the critical temperature and the point of hyperthermal rise is called the *zone of thermal neutrality*. This zone can be extended over a wider temperature range by developing rations with more HI for cold weather and less HI for hot weather.

Strict additivity in the energy equations is valid only to the extent that the overall nutrient balance is maintained. That is, the rate of substitution of one combination of ingredients for another combination of ingredients is linear in energy if the same deficiencies in other nutrients (protein, minerals, vitamins, etc.) are exactly maintained. Maynard and Loosli [9, sec. 11.16] state, "Deficiencies of phosphorus, riboflavin and certain other minerals and vitamins tend to increase the heat increment of a ration. In fact, there is evidence that, other things being equal, if the ration is unbalanced with respect to any nutrient in terms of physiological needs the wastage of heat tends to be greater accordingly." This means that the net energy value of the ration would be smaller accordingly. Linearity in the context of constrained nutrient balance does not contradict studies showing nonlinear substitution between two feedstuffs that are different in overall nutrient composition.

There may be a major exception to linearity in the case of fat; see Moody et al [12]. Again quoting from Maynard and Loosli [9, sec. 11.16]: ". . . a greater than expected value of fat as a source of energy can be explained on the basis that, with equicaloric diets, increasing the fat component decreases the heat increment." This suggests that some optimum level of fat should be specified in recommended nutrient requirements, as is done with protein. The level of protein in equicaloric diets also has a marked effect on the level of HI, and consequently the NE_m and NE_g values, with the HI decreasing with increases in protein levels up to the optimum protein levels and then increasing [9].

A Three-Equation Energy System

The system consists of an equation for each of three different energy fractions: (1) NE_m, (2) NE_g, and (3) ME.

$$(1)\qquad \alpha \sum_j a_{1j}X_j = AW^{.75}$$

$$(2)\qquad (1-\alpha)\sum a_{2j}X_j = (Bg + Cg^2)W^{.75}$$

$$(3)\qquad \sum a_{3j}X_j = ME$$

where α is the proportion of feed required for maintenance; a_{1j}, a_{2j}, and a_{3j} are, respectively, the NE_m, NE_g, and ME values of the jth feed ingredient; X_j is the quantity of the jth feed consumed; $W^{.75}$ is the *metabolic weight* of an animal where W is body weight in kg.; and g is gain in kg. per day. The right-hand sides represent energy intake in Mcal. per day. Lofgreen and Garrett [7] give the following estimates for parameters of equations (1) and (2): for steers, $B=0.05372$, $C=0.00684$; for heifers, $B=0.05603$, $C=0.01265$; for steers and heifers, $A=0.077$. In equation (3), ME is the level of metabolizable energy.

Any level of ME resulting from optimizing with respect to equations (1) and (2) is accept-

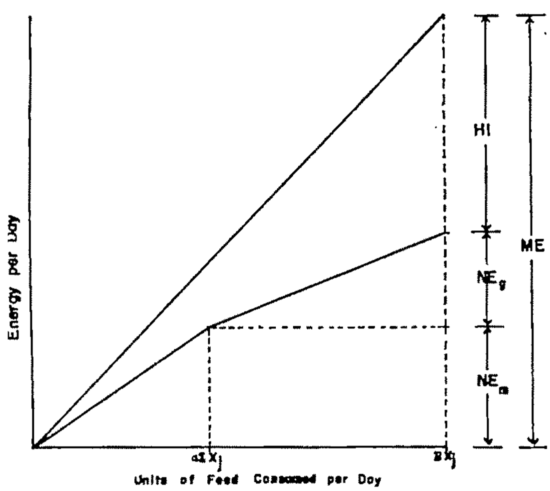

Figure 1. The relationship of three energy fractions to feed consumed per day

able in an environment of thermal neutrality. For chill stress, ME can be made larger; for heat stress, smaller. Hence, $HI = ME - NE_m - NE_g$ is indirectly varied. A graphic representation of the system is shown in Figure 1.

Linear Programming Models

The difficulty in linear programming with the Lofgreen-Garrett system, as shown in equations (1) and (2), is that both α and X_j are unknown. Since each ingredient must be multiplied by α in equation (1) and by $(1-\alpha)$ in equation (2) the system is not additive in the energy equations. However, a simple, efficient linear programming model can be developed with a few transformations.

Divide both sides of equations (1) and (2) by α and create K right-hand sides for each of $k=1, 2, \cdots, K$ possible values of α_k:

$$(5) \qquad \sum_j a_{1j}X_j = NE_m/\alpha_k$$

$$(6) \qquad \sum_j a_{2j}X_j = NE_g/(1-\alpha_k)$$

where $NE_m = AW^{.75}$ and $NE_g = (Bg + Cg^2)W^{.75}$.

Equations (5) and (6) can be easily handled in a straightforward linear programming with any specification of the parameters and any specific value of α_k. An efficient model must incorporate these right-hand sides as activities and select the optimum level of α directly in one solution. Model I is efficient in this respect.

Model I

Only the objective functions and equations dealing with the net energy and dry matter intake of the diet problem are discussed. Equations for the remaining nutrients form a simple linear system.

$$(7.1) \qquad \text{Minimize} \sum C_jX_j$$

subject to:

$$(7.2) \qquad \sum B_k = 1$$

$$(7.3) \qquad \sum a_{1j}X_j - \sum b_{1k}B_k = 0$$

$$(7.4) \qquad \sum a_{2j}X_j - \sum b_{2k}B_k = 0$$

$$\vdots$$

$$(7.m) \qquad \sum a_{mj}X_j - \sum b_{mk}B_k \leq 0$$

also

$$X_j, B_k \geq 0 \quad (j=1, \cdots, n, k=1, 2, \cdots, K)$$

where C_j is the cost per unit of the jth ingredient; X_j is the quantity of the jth ingredient, a_{1j}, a_{2j}, and a_{mj} are respectively the NE_m, NE_g, and dry matter coefficients of the jth ingredient; $b_{1k} = NE_m/\alpha_k$; $b_{2k} = NE_g/(1-\alpha)$; b_{mk} is the dry matter intake level appropriate for the specifications of requirements for NE_m and NE_g;[2] and B_k is a weighting factor for α_k or more directly for b_{1k} and b_{2k}.

Intervals of $\alpha_{k+1} - \alpha_k = .01$ are used. Obviously the optimum level of α must fall in the range $0 < \alpha \leq 1$, but a much narrower range can be specified.

In equations (5) and (6) a_{1j} can equal a_{2j} $(j=1, \cdots, n)$ only if $NE_m/\alpha = NE_g/(1-\alpha)$, in which case $\alpha = NE_m/NE_m + NE_g$. Since $a_{1j} > a_{2j}$ for all j; $\alpha < NE_m/NE_m + NE_g$. Alternatively, the proportion of feed expended for maintenance, α, is at a minimum if all $a_{1j} = a_{1*}$, where a_{1*} is the largest NE_m coefficient of all ingredients. The complement, $1-\alpha$, reaches a minimum if all $a_{2j} = a_{2*}$, where a_{2*} is the largest NE_g coefficient of all j ingredients.

Hence,

$$(8) \qquad \frac{NE_m}{a_{1*}b_m} < \alpha < 1 - \frac{NE_g}{a_{2*}b_m}$$

where b_m is the constraint level of daily dry matter intake. An initial upper limit on α is

[2] The dry matter constraint is a very important factor in determining the optimum ration. For application of this model, dry matter intake levels suggested in the NRC guidelines for beef cattle [13] were used. The NRC states that feed consumption is affected by the age and condition of an animal. Further, it is known that the level of dry matter intake is a function of the energy concentration of feed [1, 3]; however, no such functions for beef cattle are published.

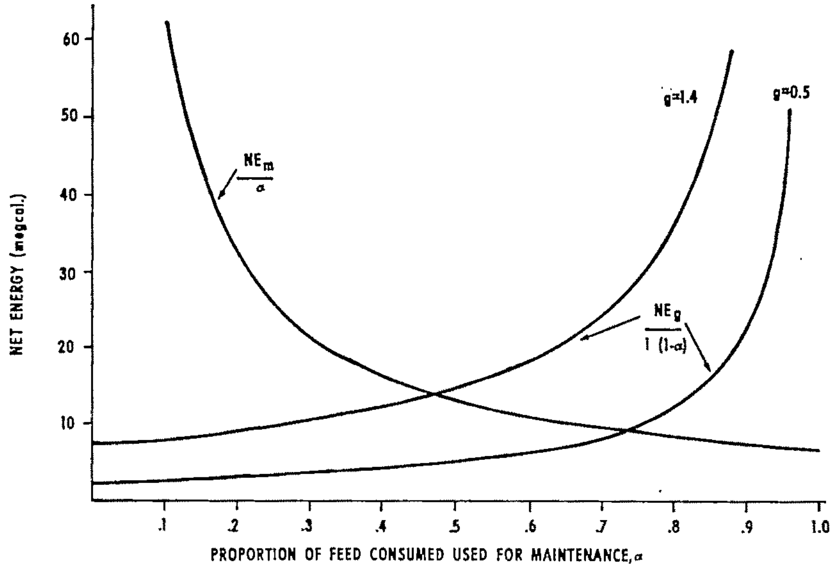

Figure 2. NE_m/α **and** $NE_g/(1-\alpha)$ **for all values of** α **(365 kg. steer, two rates of gain)**

placed at the smaller of $1-(NE_g/a_{2*}(b_m))$ or $NE_m/(NE_m+NE_g)$.[3]

Figure 2 shows the relationship of the level of α to NE_m/α and $NE_g/(1-\alpha)$. The error due to interpolation between two points on the NE_m/α curve, say between points at α_k and α_{k+p}, is expressed by (9):

$$\frac{[(B_k(NE_m/\alpha_k) + B_{k+p}(NE_m/\alpha_{k+p})] - [NE_m/(B_k\alpha_k + B_{k+p}\alpha_{k+p})]}{NE_m/(B_k\alpha_k + B_{k+p}\alpha_{k+p})} \tag{9}$$

Hence, the smaller the difference $\alpha_{k+p}-\alpha_k$, the smaller the error due to interpolation. If $\alpha_{k+1}-\alpha_k$ is very small, the solution needs to contain B_k vectors for only two adjacent values of k in order to assure that errors due to interpolation are a minimum.

Since the value of the objective function as a function of α is convex from below, not more than two B_k vectors enter the solution and more than one enters only with adjacent values of k. Hence, no special procedure such as integer programming or separable programming is required to achieve a minimum level of error due to interpolation. With the intervals $\alpha_{k+1}-\alpha_k=.01$, solution errors in NE_m/α_k due to interpolation have been in the order of 0.04 percent—virtually zero.

[3] After working with a few solutions, much narrower limits can be established. For example, if the optimum level for a particular problem is between α_r and α_{r+1}, a range of $\alpha_r-.02$ and $\alpha_r+.03$ should apply to nearly all future problems of the same specifications for daily gain. It is a simple matter to modify the problem to include a narrower or wider range on α.

In applying this model with IBM/MPS/360 a single matrix was used containing the ingredient variables and B_k variables for several weight classes and rates of gain for both steers and heifers. These variables are efficiently created on the computer, using the Lofgreen-Garrett net energy functions and arrays of data for α and for other nutrient requirements.

A solution for a particular sex, weight, and rate of gain is obtained by partitioning the matrix, with appropriate instructions to include only nutrient specification relevant to the type of animal under consideration. A sequence of solutions for different rates of gain is easily obtained for a cost of approximately $2.00 per solution.[4] This cost is sufficiently small to warrant considerable exploration of optimum rations under a variety of dietary specifications.

Model II

To formulate rations with varying levels of heat increment, a constraint for metabolizable energy is added to Model I. Constraint (7.5a) is used for reducing HI or constraint (7.5b) for increasing HI:

[4] J. A. McDonough has recently developed a very ingenious procedure for use with the Lofgreen-Garrett net energy system which obtains the least cost of gain ration directly [10].

Table 1. Tableau representation of model for three-equation energy system

Activities											Constraints			
X_1	X_2	X_3	X_4	X_5	X_6	B_1	B_2	$\cdots$	B_{16}	w	Type	value	Name	Number
C_1	C_2	C_3	C_4	C_5	C_6	0	0	$\cdots$	0	0	—	—	Costs	7.1
						1	1	$\cdots$	1		=	1	αSI[a]	7.2
2.230	2.230	1.347	0	2.010	2.030	−20.74	−20.09	$\cdots$	−13.98		=	0	NE_m	7.3[b]
1.393	1.450	.490	0	1.270	1.340	−10.55	−10.71	$\cdots$	−13.48		=	0	NE_g	7.4[c]
3.254	3.182	2.061	0	3.290	2.676						≤	$M-1(\theta)$	ME[d]	7.5[a]
0.046	0.112	0.127	2.81	0.024	0.065	− 0.79	− 0.79	$\cdots$	− 0.79		≥	0	Protein	7.6
0.092	0.034	0.298	0	0	0.174					−.08	≥	0	Fiber	7.7
0.037	0.019	0.022	0	0.001	0.005					−.08	≤	0	Ether extract	7.8
			1.0							−.01	≤	0	Urea	7.9
				1.0						−.01	≤	0	Molasses	7.10
					1.0					−.25	≤	0	Beet pulp	7.11
1.0	1.0	1.0	1.0	1.0	1.0	− 9.12	− 9.12	$\cdots$	− 9.12		≤	0	Dry matter	7.12
−1.0	−1.0	−1.0	−1.0	−1.0	−1.0					1	=	0	Dry matter	7.13

[a] αSI stands for α selection imperative.
[b] Coefficients under B_k on row 7.3 are $-6.43/\alpha$ for $\alpha = 0.31, 0.32, \cdots, 0.46$.
[c] Coefficients under the B_k on row 7.4 are $-7.28/(1-\alpha)$ for $(1-\alpha) = 0.69, 0.68, \cdots, 0.54$.
[d] For finding the maximum HI, the constraint 7.5b is used.

$$\text{(7.5a)} \qquad \sum a_{3j} X_j \leq M - 1(\theta)$$

$$\text{(7.5b)} \qquad \sum a_{3j} X_j \geq 0 + 1(\theta)$$

where a_{3j} is the ME coefficient for the jth ingredient; M is an arbitrary quantity at least as large as the ME value occurring in solutions of Model I where ME is not a binding constraint; and θ is a parameter that is varied.

When θ is a maximum in constraint (7.5a), the level of $ME = M - \theta$ is a minimum and $HI = ME - NE_m - NE_g$ is also a minimum. In constraint (7.5b) $ME = \theta$ and maximum θ gives a maximum HI for fixed levels of NE_m and NE_g.

Solutions of Model II with constraint (7.5a) for reducing HI levels is well behaved in the sense that only a single B_k vector or two adjacent B_k vectors enter the solution. However, the problem is not well behaved in obtaining increasing levels of HI with constraint (7.5b).

Solutions with θ a maximum in constraint (7.5b) always give solutions with vectors B_1, $B_K > 0$; hence, the error due to interpolation may be large.[5] A practical procedure for limiting solution errors caused by nonadjacent B_k variables is to place a narrow limit on the range of k: (1) Solve Model II with constraint (7.5a); (2) from the minimum HI solution with adjacent vectors B_r and B_{r+1}, use r as the upper value of k; (3) exclude all B_k vectors except B_{r-2}, B_{r-1}, and B_r; (4) solve Model II with constraint (7.5b) for increasing levels of HI. An efficient integer program limiting the solution to a single B_k vector might be preferable to the above four-step procedure if the ability to vary θ is not given up.

[5] The maximum error in constraint (7.3) resulting from interpolation between the extreme points, NE_m/α_1 and NE_m/α_{16}, is 3.8 percent. This value is calculated with $B_1 = B_{16} = 0.5$, $NE_m = 6.43$, $\alpha_1 = 0.31$, and $\alpha_{16} = 0.46$.

A tableau representation of Model II with constraint (7.5a) is shown in Table 1.

Solutions

Six blends (rations) are presented to illustrate the differences in HI obtainable and the interpretation of potential differences in animal performance under assumed conditions of environmental stress. The blends designated 1 and 2 refer to (1) a steer weighing 365 kg. expected to gain 1.4 kg. per day; and (2) a steer of the same weight expected to gain 1.3 kg. per day. Dietary specifications a, b, and c, respectively, refer to blends with maximum, minimum, and intermediate levels of HI.

The daily dietary specifications included the following, which were the same for ration sets 1 and 2: fiber, 8 percent minimum; ether extract, 8 percent maximum; urea, 1 percent maximum; molasses, 10 percent maximum; beet pulp, 25 percent maximum; dry matter, 9.12 kg. maximum (100 percent dry basis); and NE_m, 6.43 Mcal. For set 1, NE_g is 7.28 Mcal. per day and digestible protein is 0.79 kg. minimum per day; for set 2, NE_g is 6.69 Mcal. per day and digestible protein is 0.75 kg. minimum per day [6, 7].

The composition of ingredients is shown in Table 2 and the composition of the six blends in Table 3.

The actual feed intake due to ad libitum consumption of these blends is not known. However, if consumption in the amounts shown by the solutions occurs, the expected gains will take place under an environment of thermal neutrality (assuming the gain parameters of Lofgreen and Garrett apply). Comparison of animal performance among the six blends under thermal neutrality is shown in Table 4. Comparison of the six blends under conditions of

Table 2. Feed composition (units per kg. of ingredient 100 percent dry)

Ingredient	Reference Number	NE_m	NE_g	ME	Dig. protein	Fiber	Ether extract	Price	
		kcal.	*kcal.*	*kcal.*	*kg.*	*kg.*	*kg.*	*cents*	*cents per pound*[a]
Beet pulp w/molasses	4-00-672	2030	1340	2676	0.065	0.174	0.005	5.142	2.15
Milo	4-04-444	2130	1400	2892	0.071	0.022	0.031	4.303	1.74
Barley	4-00-530	2130	1400	3001	0.098	0.056	0.021	4.482	1.81
Wheat	4-05-211	2230	1450	3182	0.122	0.034	0.019	4.698	1.90
Corn, No. 2	4-02-915	2270	1480	3326	0.080	0.023	0.049	4.819	1.93
Oats	4-03-309	1830	1220	2748	0.099	0.124	0.051	4.559	1.84
Soybean meal	5-04-604	1930	1290	2928	0.438	0.067	0.010	12.856	5.20
Ground ear corn	4-02-849	2230	1393	3254	0.046	0.092	0.037	4.070	1.61
Cane molasses	4-04-696	2010	1270	3290	0.024	0.000	0.001	4.851	1.65
Corn silage	3-08-154	1544	970	2530	0.049	0.263	0.027	3.942	.50
Corn stover	1-02-772	1390	810	2350	0.041	0.259	0.024	.880	.33
Alfalfa hay	1-00-059	1347	490	2061	0.127	0.298	0.022	2.383	.98
Corn cobs	1-02-782	1060	250	1699	0.000	0.358	0.005	.365	.15
Barley straw	1-00-498	1010	140	1482	0.005	0.424	0.018	1.746	.70
Urea	—	—	—	—	2.810	—	—	13.750	6.25

Source: [2, pp. 478–749].
[a] As fed moisture basis.

Table 3. Composition of blends (100 percent dry basis)

Item	Heat increment level					
	Maximum		Minimum		Intermediate	
Blend number	1a	2a	1b	2b	1c	2c
Ingredients (percent)						
Ground ear corn	66.3	65.3			46.4	38.4
Milo			67.5	64.0		
Wheat					27.9	24.5
Beet pulp/w molasses			25.0	25.0		
Molasses	10.0	10.0				
Soybean meal	8.2					
Urea		0.8	0.9	0.9	0.9	0.9
Alfalfa hay	14.0	22.4				
Corn stover				8.6	23.3	34.8
Barley straw			5.1			
Vitamins and minerals	1.5	1.5	1.5	1.5	1.5	1.5
Energy (Mcal. per kg.)						
ME	3.015	2.916	2.697	2.723	2.946	2.846
NE_m	2.030	1.966	1.997	1.991	1.981	1.886
NE_g	1.225	1.147	1.287	1.301	1.240	1.172
Cost (cents per kg.)	4.67	3.88	4.49	4.33	3.62	3.23

environmental stress is shown in Table 5 for heat stress and in Table 6 for chill stress. Of the six blends, blend 2a has the highest level of HI relative to NE_g and blend 1b has the lowest level of HI relative to NE_g.

Environmental stress is defined for heat stress as a condition in which $HBC>0$ or feed intake is reduced to avoid HBC; for chill stress, as a condition in which $HBW>0$ or feed intake is increased to avoid HBW.

Interpretation under heat stress

Assume the environment is constant over a 24-hour period and that an animal in this environment reaches its point of hyperthermal rise as its total HP reaches a rate of 16.10 Mcal. per day. Further assume that the HP from NE_m, HI, and HBC is evenly distributed over this period.

Two interpretations are offered: (1) where HI is consumed at levels burdensome to the animal and the burden, B, must be expurgated by diverting energy from NE_g to HBC; (2) where the animal avoids stress by eating less.

Let B denote the quantity of burdensome HI and let δ, a heat elimination factor, denote the

Table 4. Theoretical comparisons of six blends under thermal neutrality

Item	Heat increment level					
	Maximum		Minimum		Intermediate	
Blend number	1a	2a	1b	2b	1c	2c
Feed intake (kg. per day)						
Total	9.12	9.12	8.877	8.372	9.12	9.12
For maintenance	3.167	3.271	3.22	3.230	3.246	3.409
For gain	5.943	5.849	5.657	5.142	5.874	5.711
Energy Mcal. per day						
ME	27.50	26.59	23.94	22.79	26.87	25.96
NE_m	6.43	6.43	6.43	6.43	6.43	6.43
NE_g	7.28	6.71	7.28	6.69	7.28	6.69
HI	13.79	13.45	10.23	9.67	13.17	12.84
HP						
Gain (kg. per day)	1.4	1.3	1.4	1.3	1.4	1.3
Cost						
Cents per day	42.59	35.38	39.87	36.25	33.01	29.46
Cents per kg. gain	30.42	27.22	28.48	27.88	23.58	22.66

quantity of energy required to expurgate one unit of B. Hence, the heat generated to expurgate B is δB, which in turn is eliminated by $\delta(\delta B)$, which in turn is eliminated with the same efficiency, ad infinitum:

$$(9) \qquad HBC = B(\delta + \delta^2 + \delta^3 + \cdots)$$

This series converges to

$$(9a) \qquad HBC = \frac{B\delta}{1-\delta} \qquad \text{for } -1 < \delta < 1$$

Obviously, for the case in point, $0<\delta<1$.

The burdensome HI, B, per marginal unit of feed consumed is the difference between ME per unit of the blend, a_3, and the NE_g per unit of the blend, a_2.

HBC per unit feed consumed is just equal to a_2 when δ is equal to the ratio of NE_g per unit feed to ME per unit feed:

$$HBC = a_2 = \frac{\delta}{1-\delta}(a_3 - a_2),$$

so (a) if $\delta = a_2/a_3$, additional NE_g available for gain neither increases nor decreases with additional feed consumption; (b) if $\delta > a_2/a_3$, NE_g available for gain decreases with increased feed consumption; and (c) if $\delta < a_2/a_3$, NE_g available for gain increases with increased feed consumption.

The amount of gain sacrificed in heat expurgation, once the value of δ is established, depends on the amount of NE_g per unit of feed relative to the HI per unit of feed. The advantage under heat stress lies with rations that have high ratios of NE_g per unit HI for two reasons: first, the amount of NE_g at the point of hyperthermal rise is greater; and second, for every unit of heat that must be eliminated there is a larger amount of NE_g to be diverted.

For comparing rations with unequal levels of burdensome HI, the value of δ is set equal to the ratio a_2/a_3 of blend 1b ($\delta = 0.447$).[6] Therefore, blend 1b falls in category (a) above, and the NE_g concomitant with the burdensome HI is just sufficient for the necessary HBC. The remaining blends fall in category (b). Thus, except for blends 1b and 2b, the gains are higher in the second part of Table 4, but consumption levels are higher in the first part.

A graphical representation of the various energy fractions under heat stress for blends 2a and 1b is shown in Figure 3, first for the case where energy is diverted from NE_g to HBC and second for the case where stress is avoided by reducing the consumption to the level where no burdensome HI occurs. The numbers on the vertical axes refer to the NE_g, NE_m and ME per kg. of the blend in ascending order. Numbers on the horizontal axes refer to levels of feed consumption per day. Hence, in the upper left diagram of Figure 3 the total NE_m per day is represented by the area formed by multiplying NE_m per kg. of the feed times the kg. of feed consumed. The overall area is ME which is divided into NE_m, HI, B, NE_g, and HBC.

Under thermal neutrality, 9.12 kg. of blend

[6] This value is arbitrary and is used only to illustrate differences in HBW associated with different levels of HI relative to NE_g.

Table 5. Theoretical comparisons of six blends with two heat stress reactions (point of Hyperthermal rise @ HP = 16.10 Mcal./day, heat elimination factor @ δ = 0.477)

Item	Heat increment level					
	Maximum		Minimum		Intermediate	
Blend number	1a	2a	1b	2b	1c	2c
			Heat burden eliminated			
Feed intake (kg. per day)						
Total	9.12	9.12	8.877	8.372	9.12	9.12
For maintenance	3.167	3.271	3.220	3.230	3.246	3.41
For gain	5.943	5.849	5.657	5.142	5.874	5.71
Energy (Mcal. per day)						
ME	27.50	26.59	23.94	22.79	26.87	25.96
NE_m	6.43	6.43	6.43	6.43	6.43	6.43
NE_g	7.28	6.71	7.28	6.69	7.28	6.69
Diverted to HBC	3.76	3.45	0.51	0	3.19	2.89
Left for gain	3.52	3.26	6.77	6.69	4.09	3.80
HI total	13.79	13.45	10.23	9.67	13.17	12.84
Burdensome $HI(B)$	4.12	3.78	0.56	0	3.50	3.17
HP (NE_m+HI+HBC)	23.96	23.33	17.17	16.10	22.79	22.16
Gain (kg. per day)	0.73	0.61	1.32	1.30	0.84	0.78
Cost						
Cents per day	42.59	35.38	39.87	36.25	33.01	29.46
Cents per kg. gain	58.34	52.03	30.44	27.88	45.85	44.64
			Heat burden avoided			
Feed intake (kg. per day)						
Total	6.827	6.980	8.48	8.372	7.078	7.231
For maintenance	3.167	3.271	3.220	3.23	3.246	3.409
For gain	3.660	3.709	5.260	5.142	3.832	3.822
Energy (Mcal. per day)						
ME	20.58	20.35	22.87	22.79	20.85	20.58
NE_m	6.43	6.43	6.43	6.43	6.43	6.43
NE_g	4.48	4.25	6.77	6.69	4.75	4.48
HI	9.67	9.67	9.67	9.67	9.67	9.67
HP	16.10	16.10	16.10	16.10	16.10	16.10
Gain (kg. per day)	0.91	0.87	1.32	1.30	0.96	0.91
Cost						
Cents per day	31.88	27.08	38.08	36.23	25.62	23.36
Cents per kg. gain	35.03	31.13	28.85	27.88	26.69	25.67

2a results in a gain of 1.3 kg. per day at a cost of 27.22 cents per kg. of gain. With this same level of consumption under the assumed heat stress conditions, 3.45 Mcal. of the original NE_g is diverted to HBC, leaving only 3.26 Mcal. which is enough for only 0.61 kg. gain. Had the animal instead reduced its intake to 6.98 kg., it would have entirely avoided the burdensome HI and could have gained 0.87 kg. per day, or 0.19 kg. more per day. The ingredient cost per kg. gain would have been reduced from 52.03 cents to 31.13 cents.

Similar comparisons for blend 1b show that the gain of 1.4 kg. under thermal neutrality is reduced to 1.32 kg. under the stress conditions, whether by diverting 0.51 Mcal. to HBC to eliminate the burdensome HI or by reducing consumption by 0.40 kg. to avoid the burden. The cost per kg. gain is increased from 28.4 cents under thermal neutrality to 30.44 cents in the case of heat elimination or to 28.85 cents in the case of reduced feed intake.

In reality, heat elimination may be highly efficient except under very severe heat and humidity. Hence, only small amounts of energy may be expended in HBC, with the major loss in gain and consequent loss in feed efficiency under heat stress due to reduced feed intake.

High producing animals must eat large quantities of NE_p and consequently large

Table 6. Theoretical energy fraction comparisons for six blends with three chill stress reactions. (Critical temperature @ HI = 14.35 Mcal.)

Item	Heat increment level					
	Maximum		Minimum		Intermediate	
Blend number	1a	2a	1b	2b	1c	2c
			Unequal gain, unequal *HBW*			
Total kg.	9.12	9.12	8.877	8.372	9.120	9.120
For maintenance	3.167	3.271	3.220	3.230	3.246	3.409
For gain	5.943	5.849	5.657	5.142	5.874	5.711
Energy						
ME	27.50	26.59	23.94	22.79	26.87	25.96
NE_m	6.43	6.43	6.43	6.43	6.43	6.43
NE_g	7.28	6.71	7.28	6.69	7.28	6.69
Diverted to *HBW*	.56	.89	4.12	4.68	1.18	1.51
Left for gain	6.72	5.82	3.16	2.01	6.10	5.18
HI	13.79	13.45	10.23	9.67	13.17	12.84
HP	20.78	20.78	20.78	20.78	20.78	20.78
Gain	1.30	1.15	.66	.43	1.20	1.04
Cents per day	42.59	35.39	39.86	36.25	33.01	29.46
Cents per kg. gain	32.76	30.77	60.39	84.30	27.51	28.33
			Equal gain, unequal *HBW*			
Total kg.	9.306	9.621	10.405	10.306	9.524	9.860
For maintenance	3.167	3.271	3.220	3.230	3.246	3.409
For gain	5.943	6.347	5.657	5.596	5.871	6.212
For extra *HP*	.196	0.003	1.528	1.480	0.407	0.239
Energy						
ME	28.06	28.05	28.06	28.06	28.06	28.06
NE_m	6.43	6.43	6.43	6.43	6.43	6.43
NE_g						
Diverted to *HBW*	0.24	0.003	1.97	1.93	0.50	0.28
Left for gain	7.28	7.28	7.28	7.28	7.28	7.28
HI	14.11	14.35	12.38	12.42	13.85	14.07
HP	20.78	20.78	20.78	20.78	20.78	20.78
Gain	1.4	1.4	1.4	1.4	1.4	1.4
Cents per day	43.46	37.32	46.71	44.62	34.48	31.84
Cents per kg. gain	31.04	26.66	33.36	31.87	24.63	22.74
			Unequal gain, zero *HBW*			
Total	9.441	9.625	11.799	11.658	9.821	10.027
For maintenance	3.167	3.271	3.220	3.230	3.246	3.409
For gain	6.274	6.354	8.579	8.428	6.575	6.618
Energy/day Mcal.						
ME	28.46	28.07	31.82	31.74	28.93	28.54
NE_m	6.43	6.43	6.43	6.43	6.43	6.43
NE_g	7.68	7.29	11.04	10.96	8.15	7.76
HI	14.35	14.35	14.35	14.35	14.35	14.35
HP	20.78	20.78	20.78	20.78	20.78	20.78
Implied kg. gain per day	1.47	1.40	1.99	1.98	1.54	1.48
Cents per day	44.09	37.35	52.99	50.44	35.56	32.39
Cents per kg. gain	30.00	26.68	26.63	25.47	22.94	2.189

quantities of the *HI* associated with it. Therefore, adjustment in rations during hot weather would be more important for a dairy cow producing at an annual rate of 7,000 kg. than for one producing at a 4,500-kg. rate. Likewise, a beef steer capable of gaining 1.7 kg. per day might benefit significantly from lowering the *HI* relative to NE_g, while no benefits would accrue to an animal capable of gaining only 1 kg. per day.

Interpretation under chill stress

Assume an environment in which an animal approaches the lower limit of its zone of thermal

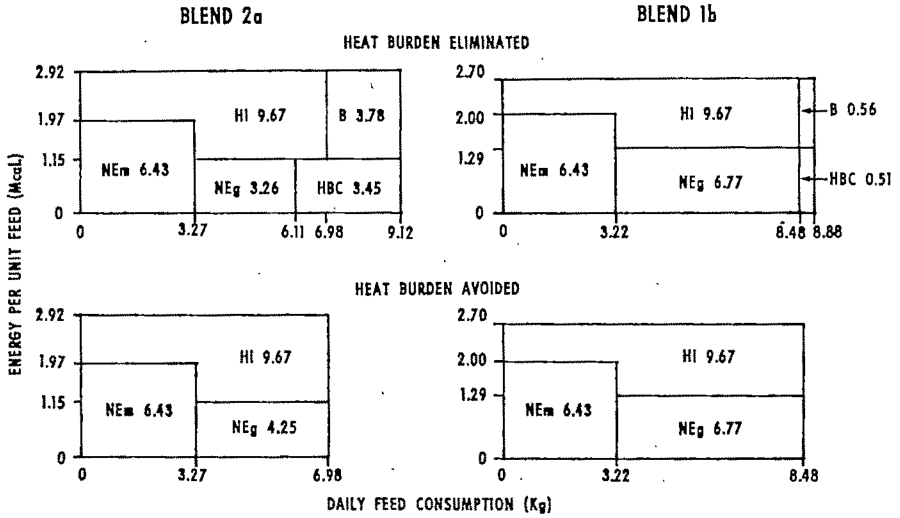

Figure 3. Energy fraction comparisons of two blends with two heat stress reactions (point of hyperthermal rise @ $HI = 9.57$ Mcal. per day and heat elimination factor, $\delta = 0.447$)

neutrality (its critical temperature) as its ration of blend 2a approaches 9.62 kg. per day. Total heat production is 20.79 Mcal. per day with a maximum HI of 14.35 Mcal. which is fully used for maintenance of body temperature. Since the $NE_m = 6.43$ Mcal. per day for all rations, discussion focuses on the magnitude of HI relative to NE_g. The NE_g level is 7.28 Mcal. or enough for 1.4 kg. gain per day. Again assume that climatic conditions and HP from NE_m, HI, and HBW are constant through time for the 24-hour period.

Three sets of comparisons are summarized in Table 6 for all six blends and in Figure 4 for blends 2a and 1b. In the first set of comparisons the intake of all six blends is set at the levels used in Table 2 for an environment of thermal neutrality. None of the rations measures up to 14.35 Mcal. of HI necessary to achieve the critical temperature. The deficit in each case is

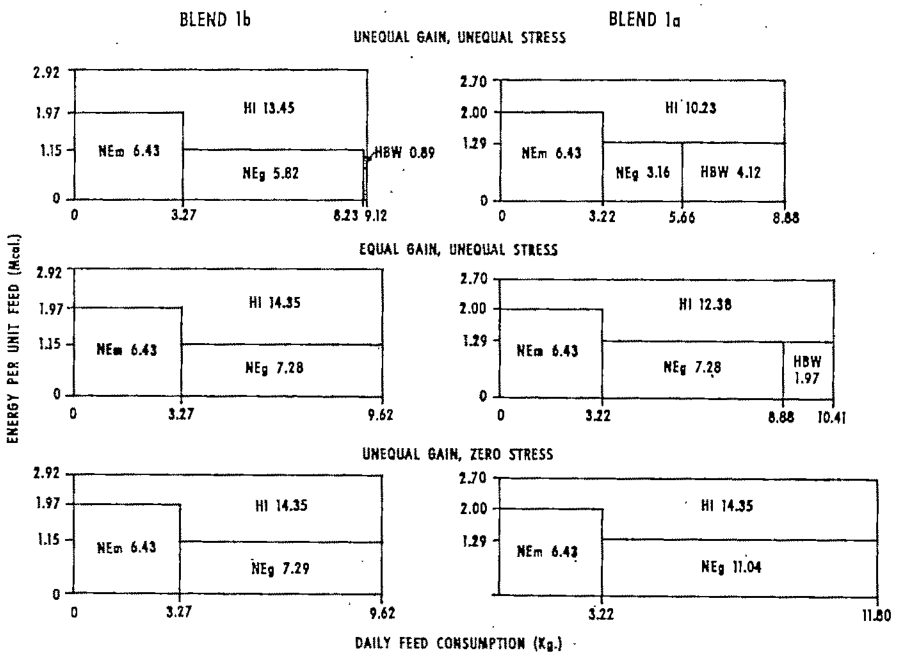

Figure 4. Energy fraction comparison of two rations with three chill stress reactions (critical temperature @ $HI = 14.35$ Mcal.)

shown as HBW, which is diverted energy otherwise usable for NE_g. The HBW is 0.89 and 4.12 Mcal., respectively, for the specified intake of blends 2a and 1b. The NE_g remaining is 5.82 and 3.16 Mcal. which is enough, respectively, for 1.15 and 0.66 kg. gain per day.

In the second set of comparisons the intake of all rations is adjusted upward to a level that secures 7.28 Mcal. of NE_g net of that transferred to HBW. This example shows that chill stress might lead to an increase in feed intake without increases in weight gain per day. In this case the animal may suffer chill stress ($HBW > 0$) as its critical temperature is reached even though gains are not effected. The economic consequences of chill stress are reduced if the animal adjusts its consumption upward to meet additional heat requirements from both HI and HBW.

The third set of comparisons shows the rations of each blend necessary for an animal to reach its critical temperature. As shown in Figure 4, blend 1b would have to be consumed in the amount of 11.8 kg. to achieve the critical temperature. The accompanying NE_g is 11.04 Mcal. for an implied gain of 1.99 kg. per day. Few, if any, 365-kg. animals can achieve such a large gain. Hence, it is very improbable that the animal will consume blend 1b in quantities large enough to achieve his critical temperature in the assumed environment.

Economic interpretation

A full assessment of the economic implications of changing HI vis-à-vis environmental stress is not attempted in this paper, which is more limited in scope.

The introduction of an additional binding constraint always results in cost equal to or greater than before. Thus, blends 1c and 2c, which were obtained with no restrictions on the amount of heat increment, are much less costly than blends 1a, 2a, 1b, and 2b and would be much preferred in environments of thermal neutrality. The economic issue of concern is whether the additional cost of adjusting the blends for stress conditions is worth the advantage of the resulting improvement in performance.

Under heat stress, blends 1b and 2b are more efficient in both energy utilization and cost of gain than the other blends either when (a) diverting NE_g for HBC to eliminate the heat burden or (b) avoiding the heat burden by reducing feed intake. However, the reduction in cost could be greater or smaller under different sets of ingredient prices.

The blends presented here represent extreme cases for HI in the context of the dietary specifications made and ingredients considered. A more economical blend for heat stress conditions may be one with HI intermediate between blends 1b and 1c or between blends 2b and 2c. For example, the HI level and cost for every solution proceeding from the least-cost blend to the blends with minimum and with maximum HI are shown in Figure 5. From HI of 12.84 Mcal. for blend 2c, a reduction of HI of 1.72 Mcal. per day was secured at an increase in cost of 1.08 costs per day, or 3.7 percent per day. The reduction of 3.17 Mcal. of HI to the minimum HI in blend 2b of 9.67 Mcal. was secured for an additional cost of 6.82 cents, or 23.2 percent per day.

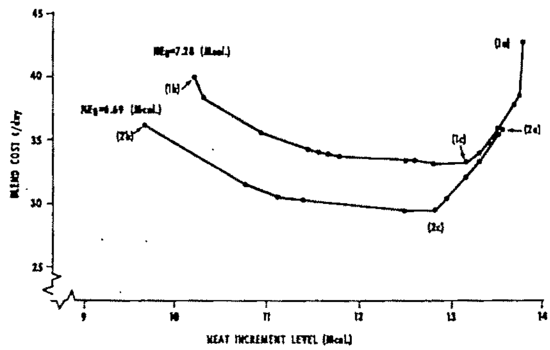

Figure 5. Blend cost vs. heat increment level for two levels of NE_g (each dot represents a solution point)

Since forages have higher relative HI than concentrates, more economical reduction in HI might be secured if it were possible, as some evidence indicates, to reduce the level of the fiber content (used in this analysis as a proxy for roughage requirements). The advantage claimed for low roughage rations and rations with inert materials substituted for roughage should be examined in light of the HI aspect of low roughage rations. If the low HI is a factor in the performance of low roughage rations, advantages may be underestimated in hot weather and overestimated in cold weather.[7]

Since the HI levels are very near the maximum obtainable levels for the least-cost blends, blends 1c and 2c are shown to have the least

[7] Using data in Table 2, the heat increment relative to NE_g, $(ME - NE_g) \div NE_g$ for concentrates varies from 0.997 for beet pulp to 1.591 for cane molasses, while for roughages this ratio varies from 1.608 for corn silage to 9.586 for barley straw.

cost per unit gain in all three sections of the chill stress comparisons in Table 6. However, there is a substantial advantage indicated for the rations with maximum HI over rations with minimum HI, and under different price ratios the advantage of increasing HI for chill stress could be large.

As stress conditions become more extreme it may be economical to modify the NE_g specifications to allow greater flexibility in changing HI. For example, the HI level relative to NE_g is higher for blend 2a than for 1a. A further reduction of the NE_g specification would yield an even higher ratio of HI per unit NE_g.

Clearly, much additional exploration is needed with (1) an expanded list of ingredients; (2) several sets of prices representative of ingredient prices in several regions of the country; (3) changes in specifications for rates of gain, required levels of roughages, and fat content; and (4) rations with HI levels intermediate between the extremes.

If changing relative HI levels in rations during periods of heat or chill stress is economic, information on the conditions under which stress occurs becomes important. Functions or distributions showing the rate at which HI occurs over time following feeding are needed. There is substantial literature describing the variables involved in environmental stress [4, 11, 12, 16, 17] and the general effects on animals during stress. Practically no quantitative information is available on the extent and duration of stress and its consequences to feed efficiency.

Summary

A theoretical framework for blending rations to improve performance of beef cattle under heat or chill stress is presented. The framework and computational procedures used involve a systematic variation of the heat increment in rations with constant amount of net energy for maintenance and net energy for gain. The heat increment of a ration is useful for maintenance of body temperature in chill stress but is burdensome and must be expurgated in heat stress.

The energy system used employs three equations, two of which are the net energy equations of the Lofgreen-Garrett net energy system. The third is for metabolizable energy. The solution requires techniques developed by the author for the Lofgreen-Garrett system, along with parametric programming on metabolizable energy so as to vary indirectly the heat increment. Two sets of three rations with the maximum, minimum, and intermediate levels of HI were obtained. Comparisons under different assumed environmental conditions indicate how much improvement in animal performance can be obtained by changing the rations when environmental stress occurs. Economic analysis indicates that the increased ration cost of adjustments in HI to meet stress conditions can be more than offset by the benefits of the resulting improvement in performance. Whether this is so depends on ingredient prices, the degree of stress, and how the animal adjusts feed intake when stress conditions occur.

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The Regional Impact of Lamb Imports on Equilibrium Returns to Domestic Producers, 1967*

HOY F. CARMAN AND JAMES A. MAETZOLD

There is little agreement on producer costs and consumer benefits resulting from meat imports. This paper utilizes a spatial equilibrium model to analyze the regional impact of three levels of lamb imports on United States lamb producers and consumers. Results demonstrate regional as well as quarterly variation. Most of the variation is explained by quarterly marketing patterns, shifts in demand, changes in optimum distribution patterns, changes in levels of imports and ports of entry, and restricted ports of entry for imports.

UNITED STATES lamb producers have been voicing concern over recent increases in chilled and frozen lamb imports, products not covered by present meat quota laws.[1] Lamb imports averaged about 12.75 million pounds annually between 1964 and 1967, or approximately 2 percent of estimated U.S. lamb production. Sharp increases raised 1968 lamb imports to 23 million pounds [13, p. 22] and 1969 imports to 44 million pounds [14, p. 26]. Imports in 1969 equalled 8.6 percent of estimated U.S. lamb production.

The impact of meat imports—and more specifically, lamb imports—on returns to domestic producers is a subject on which there is little agreement. Producer groups and their representatives argue that uncontrolled lamb imports reduce domestic prices and are a factor in recent declines in domestic sheep numbers. At the other extreme, representatives of meat importers argue that, because of intensive promotion of imports and nonavailability of domestic lamb during some time periods, the demand (and price) for lamb is higher than it would be without imports.[2]

Our analysis shows that imports have both costs and benefits for the receiving country, costs in the form of decreased returns to domestic producers, benefits in the form of increased supplies of meat at lower prices to consumers. Results of the analysis provide estimates of the regional costs of imports to producers as well as consumer benefits under conditions existing in 1967.[3] The analysis is performed on a quarterly basis for 20 regions in the United States. Producer costs and consumer benefits are examined for three levels of imports.

Theoretical Framework

An extension of the well-known two-region spatial equilibrium model is utilized for the analysis. Market equilibrium for the simple two-region case is illustrated in the top portion of Figure 1. Before trade, quantity q_1 was sold at price p_1 in region A and quantity q_2 was sold at price p_2 in region B. Since the difference in price $(p_1 - p_2)$ is greater than the cost of transportation, T, trade will occur; region B will ship quantity $q_3 - q_4$ to region A. This will result in new equilibrium prices p_3 in region A and p_4 in region B, the difference between the prices $(p_3 - p_4)$ being equal to the cost of transportation between the two regions.

The U.S. lamb industry is characterized by seasonality and regionality of both supply and demand. It is thus reasonable to expect the price impact of imports to vary by region because of (1) seasonal variation in the quantity of imports, (2) seasonal variation in regional lamb sales, (3) changes in optimal distribution patterns due to lamb imports, and (4) restricted ports of entry for imports. The last two points deserve clarification. Ocean transportation limits entry of lamb imports to regions with port facilities. The majority of lamb imports enter the northeastern United States, a deficit producing region; most of the remainder enters west coast ports. Major ports include Baltimore, New York, and Philadelphia.

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[1] Public Law 88-482, enacted in August 1964, establishes import quotas for fresh, chilled, or frozen cattle meat and meat of goats and sheep other than lamb [16].

[2] For statements by the Meat Importers Council of America, see [10].

[3] This paper is an extension of part of a larger study of the domestic lamb industry; see [9].

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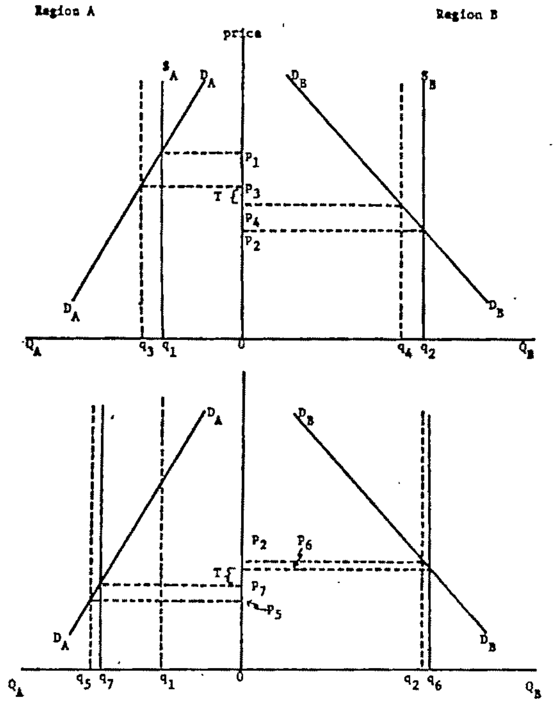

Figure 1. Competitive equilibrium between regions A and B before and after trade and after imports enter region A

Since the West Coast is an important lamb producing region, it is easy to visualize a situation in which increased imports would change western regions from a deficit to a surplus status relative to other regions. Under the assumptions of Model III this situation does occur in the second quarter, and its impact on producer prices is dramatic. The lower portion of Figure 1 illustrates the impact of imports from another country entering region A, which formerly imported from region B. The initial impact of imports equal to $q_5 - q_1$ entering region A would be to depress prices to p_5. These imports will substitute for shipments from region B, since it is no longer profitable for region B to ship to region A. Even after region B stops shipping to region A, prices in region A are lower than in region B by more than the cost of transportation. Under equilibrium conditions, region A will ship quantity $q_5 - q_7$ to region B. The new equilibrium prices, p_6 and p_7, again differ by the cost of transportation between the regions, but region A is now shipping lamb to region B. Whenever the situation just described occurs, the price impact of imports will be at least two times the transportation charge $(p_3 - p_4)$ greater in region A than in region B.

The Model

The transhipment model, a modification of the standard transportation model, is utilized for the analysis.[4] This model minimizes regional production and transfer costs for shipment of primary and intermediate goods by a sequence of points to final demand regions. Regional equilibrium of supply and demand occurs by (1) consumption of locally produced lamb, (2) importing lamb meat from other regions, (3) exporting lamb meat to other regions, and (4) importing or exporting feeder lambs for feeding. Thus, the analysis is concerned with lamb production, feeding, transportation, and consumption. The direct solution of the model provides least-cost shipment patterns for feeder lambs and lamb meat; the dual solution yields equilibrium retail and farm prices, regional price differentials, and location rents.

A quarterly analysis is performed for 20 supply and demand regions in the United States.[5] Three models analyze the distribution patterns and producer returns for lamb under various levels of imports. All models are based on estimates of 1967 regional and quarterly marketing patterns, cost of production, transportation costs, slaughter weight, and dressing percentages.[6] It is assumed that lambs are slaughtered in the region where they reach slaughter weight.[7]

Model characteristics are:

Model I—There are no lamb imports from other countries.

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[4] For a presentation and reformulation of the transhipment model, see [5] and [4].

[5] The regional demarcation is as follows: 1, Oregon, Washington; 2, California; 3, Idaho; 4, Utah, Nevada; 5, Arizona; 6, New Mexico; 7, Colorado; 8, Wyoming; 9, Montana, North Dakota; 10, South Dakota, Nebraska; 11, Kansas, Oklahoma; 12, Texas; 13, Arkansas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina; 14, Missouri, Illinois; 15, Iowa; 16, Minnesota, Wisconsin; 17, Michigan, Indiana, Ohio; 18, Kentucky, Tennessee; 19, Virginia, West Virginia; and 20, New England States, New York, New Jersey, Delaware, Maryland, Pennsylvania.

[6] Estimating procedures and data on costs of production, transportation costs, and quarterly marketings are included in [9].

[7] One reviewer correctly pointed out that lamb slaughter capacity is limited in some regions and, in fact, not all lambs are slaughtered in the region where they reach slaughter weight. Since the purpose of this analysis is comparative rather than predictive, this limiting assumption has little effect on conclusions drawn from the study. Equilibrium results will tend slightly to underestimate total transportation costs and overestimate total producer returns.

Table 1. Estimated quarterly U. S. retail demand for carcass lamb, constrained regression, linear in logarithms, 1949–1967[a]

Time period	Constant term	Variables					R^2	d^c
		Price of lamb	Price of beef	Price of pork	Price of fryers	Income[b]		
		regression coefficients						
Quarter:								
First	−4.5407	−2.0839[d]	.9318	.0428	.1358	.5712	.79	1.91
		(−4.3239)[e]	(2.3344)	(.1311)	(1.0196)			
Second	−4.1526	−2.0592	.6314	.7441	.3519	.5712	.70	2.75
		(−5.7758)	(2.5593)	(2.4684)	(2.2423)			
Third	−4.5183	−1.2679	.1619	−.2750	.4109	.5712	.73	2.27
		(−4.7469)	(.7358)	(−1.0882)	(4.1655)			
Fourth	−4.3406	−1.9867	1.5229	−.0342	.0497	.5712	.76	2.55
		(−5.9730)	(5.3361)	(−.1008)	(.6477)			

[a] For details on the estimation of these demand functions see [9]. Price elasticities are estimated subject to the constraint of the income coefficient.
[b] The income coefficient is based on 1965 cross-section data.
[c] The Durbin-Watson test indicated no serial correlation existed in the second quarter equation and was inconclusive for the other equation.
[d] Since the equation is fit in logarithms, the coefficients can be interpreted as elasticities.
[e] Values in parentheses are "t" statistics.

Model II—There are 13.146 million pounds of lamb imports from other countries.[8]

Model III—There are 26.292 million pounds of lamb imports from other countries.

The Analysis

Demand

The demand for lamb utilized in this study is the quarterly retail level demand for carcass lamb. No distinction is made between fat and fed lamb or between domestic and imported lamb.[9] Data limitations prevent an examination of the impact of promotional expenditures on the demand for lamb. Quarterly demand functions estimated by single equations linear in logarithms with per capita consumption of lamb the dependent variable, are presented in Table 1.[10] The income coefficient is based on cross-section data; thus the price and cross elasticities of demand are estimated subject to the constraint of the income coefficient. Signs on all of the coefficients except the price of pork in the third and fourth quarters were in agreement with a priori expectations. Neither of these two pork price coefficients was significantly different from zero.[11]

Income elasticities were estimated from cross-section data collected during the 1965 Food Consumption Survey [12]. Results of estimating cross-section demand equations, with quantity the dependent variable, are presented in Table 2.[12] Since data were available only for Spring, we assume that income elasticity of demand is the same for all quarters. Results appear reasonable, except for the negative income coefficient

[8] This is the product weight of 1967 lamb imports. For the analysis, this figure was converted to a 1,000-pound carcass equivalent by multiplying by a factor of .00182.

[9] These assumptions are necessary because of data limitations; see [7, p. 116]. Fat lambs, fed lambs, and imports, while substitutes, usually have separate price ranges. Part of the price difference between fat and fed lambs is reflected in the quarterly demand function, since the majority of fat lambs are sold in the second and third quarters while most fed lambs are sold in the first and fourth quarters. Fat lambs are sold directly off the ewe, four to six months after birth at approximately 90 to 110 pounds. Fed lambs are fattened two to four months in feedlots or on pasture and are sold at a weight of 90 to 115 pounds.

[10] For details on the estimation of these demand functions see [9]. Both price-dependent and quantity-dependent forms of the demand equations were estimated. The quantity-dependent form was more satisfactory, in terms of the signs and magnitudes of coefficients agreeing with a priori expectations, than the price-dependent form. The quantity-dependent form also yields direct estimates of price and cross elasticities of demand which are required in the development of regional demand functions.

[11] Results of the demand analysis utilized in this study are generally consistent with other studies. Logan and Boles found that the demand for lamb is seasonal, with quarterly demand functions showing shifts in both intercept and slope values [8, p. 1058]. Brandow found the price elasticity of demand for lamb was −2.35 at retail and −1.78 at the farm level during the 1955 to 1957 period. He also estimated the income elasticity of lamb at +.65, which was the largest value for the meats he considered [1, p. 17]. Also see [7, p. 89] and [11, pp. 85–90].

[12] For a definition of household region as utilized in the Household Food Consumption Survey, see [12].

Table 2. Cross-section demand functions for lamb, by household region, 1965[a]

Region	Constant	Income coefficient	R^2
Northeast	−4.5313	1.0826 (4.194)[b]	.66
North Central	−3.2754	.5034 (1.779)	.26
South	−3.4244	.5075 (2.030)	.31
West	−.8870	−.0787 (−.297)	.01
United States	−3.1484	.5712	.76

Source: Unpublished worksheets estimated by P. S. George in connection with his study of the demand for food [3]. (Available from G. A. King, Department of Agricultural Economics, University of California, Davis.)

[a] The coefficients are based on log functions and can thus be interpreted as income elasticities.

[b] Values in parentheses are "t" statistics.

for the West. However, as shown, it was not significantly different from zero.

Since neither price nor quantity data are considered adequate for estimating statistical demand functions separately for each region, a procedure similar to that employed by King and Schrader was utilized [6, pp. 357–362]. The constant price and cross elasticities estimated in the quarterly demand functions are utilized to derive linear approximations of regional demand. The general linear equation is

$$Q = a + b_1P + b_2I + \sum_{k=3}^{5} b_kS_k$$

where

Q = per capita consumption of lamb,
a = constant,
P = average retail price of carcass lamb in dollars per pound,
I = per capita disposable income, and
S_k = average retail prices of substitute meats in dollars per pound, $k=3$ is beef, $k=4$ is pork, and $k=5$ is fryers.

Working from the price elasticity formula,

$$Ep = \frac{\partial Q}{\partial P}\cdot\frac{\overline{Q}}{\overline{P}}$$

and since the equation is linear,

$$b_1 = \frac{\partial Q}{\partial P}$$

or

$$b_1 = Ep\,\frac{\overline{Q}}{\overline{P}}$$

and similarly for the income and substitute effects,

$$b_2 = E_I\,\frac{\overline{Q}}{\overline{I}}, \qquad b_k = E_{sk}\,\frac{\overline{Q}}{\overline{S}_k}$$

and the constant is

$$a = \overline{Q} - b_1\overline{P} - b_2\overline{I} - \sum_{k=3}^{5} b_k\overline{S}_k$$

where the bar indicates the average value for 1967.

The per capita demand for lamb in region i for quarter j can be expressed as

$$Q_{ij} = a_j + b_{1j}P_{ij} + b_{2j}I_{ij} + \sum_{k=3}^{5} b_{kj}S_{kij}.$$

Since the price and quantity of substitute meats are taken as given for the quarter involved, the effect of substitutes is included in the constant term, or

$$a_{ij^*} = a_j + \sum_{k=3}^{5} b_{kj}S_{kij}$$

and the per capita demand function for lamb is then

$$Q_{ij} = a_{ij^*} + b_{1j}P_{ij} + b_{2j}I_{ij}.$$

Quarterly per capita demand functions for lamb for the four household regions are derived utilizing the above procedure. The derivation of the linear equation for the Northeast household region for the first quarter is as follows:

The first quarter demand equation from Table 1 is

$$Q = -4.5407 - 2.0839P + .9318S_3 + .0428S_4 + .1358S_5 + 1.083I,$$

with the income coefficient for the Northeast (from Table 2) substituted for the U.S. income coefficient. Linear price and income coefficients are calculated from the direct and cross elasticities; for example,[13]

$$b_1 = -2.0839\,\frac{1.1}{.7357} = -3.1156.$$

[13] Average values of the variables for the first quarter in 1967 were: $P=\$.7357$, $S_3=\$.6137$, $S_4=\$.6670$, $S_5=\$.3810$, $Q=1.1$ pounds, and $I=\$2630$.

Table 3. Quarterly per capita demand functions for lamb, by household region, 1967

Quarter	Household[a] region	Calculated coefficients: Intercept	Price of lamb	Income
1	NE	2.7735	−3.1156	.00041
	NC	2.1125	−3.1156	.00020
	S	2.0604	−3.1156	.00024
	W	3.8851	−3.1156	−.000031
2	NE	2.2219	−2.4681	.00033
	NC	1.6802	−2.4681	.00017
	S	1.6705	−2.4681	.00019
	W	3.1238	−2.4681	−.000027
3	NE	1.5300	−1.6064	.00037
	NC	1.0429	−1.6064	.00019
	S	1.0174	−1.6064	.00022
	W	2.5527	−1.6064	−.000029
4	NE	2.1373	−2.2593	.00033
	NC	1.6108	−2.2593	.00017
	S	1.6015	−2.2593	.00019
	W	3.0411	−2.2593	−.000027

[a] The 20 regions utilized in the analysis, as listed in footnote 5, are located in the following household regions: Northeast, region 20; North Central, regions 9, 10, 11, 14, 15, 16, and 17; South, regions 12, 13, 18, and 19; and West, regions 1, 2, 3, 4, 5, 6, 7, and 8.

Similar calculations for the coefficients for substitute meats and income yields the linear equation,

$$Q = a - 3.1156P + 1.6702S_3 + .0706S_4 + .3921S_5 + .00041I.$$

To solve for the constant, we set the above equation equal to estimated first quarter Northeast household region consumption of 2.7812 pounds. Including the effect of substitutes in the constant term, the per capita demand function for the Northeast for the first quarter is

$$Q = 2.7735 - 3.1156P + .00041I.$$

Quarterly per capita demand functions for lamb derived by the above procedure are presented for the four household regions in Table 3.

Regional retail level demand relationships were then derived from the functions in Table 3 by the following procedure:

(1) Select the household demand function for the region being considered.

(2) Multiply regional per capita disposable income by the income coefficient and include in the intercept value.

(3) Multiply the per capita demand function by population to obtain regional demand.

This procedure can be illustrated for region 20 for the first quarter. Since region 20 is located in the Northeast household region, the appropriate equation (from Table 3) is

$$Q = 2.7735 - 3.1156P + .00041I.$$

Estimated per capita income for region 20 in 1967 was $3,100 and estimated population was 52,681,000. Adding the income effect to the intercept term and multiplying by population yields the regional demand function,

$$Q = 213{,}068{,}304 - 164{,}132{,}923P.$$

A summation of total demand over 20 regions for a quarter is used in the iterative solution of the transhipment model.[14]

Supply

There is marked regional variation in the percentage distribution of fat and fed lamb sales by quarter. Table 4 shows that the largest

[14] The solution procedure is described by King and Schrader [6, p. 362]. Regional demand functions by quarter, regional population, and regional per capita disposable income are presented in [9].

Table 4. Total number of fat and fed lambs sold, by region, and percentage distribution of sales, by quarter, 1967[a]

Region	Total number of fat and fed lambs sold	Distribution of sales by quarter: Q_1	Q_2	Q_3	Q_4
	thousands	percent			
1	449.3	19.1	27.2	38.3	15.4
2	944.6	22.9	41.5	14.6	21.0
3	598.3	22.4	29.7	34.0	13.9
4	360.9	19.1	4.6	55.5	20.8
5	273.3	37.4	44.6	—	18.0
6	216.7	26.9	6.4	19.3	47.4
7	1,152.2	42.1	10.6	9.3	38.0
8	202.3	38.0	11.1	15.9	35.0
9	623.5	30.2	9.9	33.7	26.2
10	1,127.8	43.3	16.1	9.4	31.2
11	404.0	26.8	50.1	7.6	15.5
12	783.8	26.9	24.3	26.6	22.2
13	29.3	6.1	65.0	22.1	6.8
14	582.5	26.8	27.8	21.3	24.1
15	957.7	27.8	18.7	33.5	20.0
16	635.4	24.1	17.1	39.6	19.2
17	974.4	22.0	23.7	38.4	15.9
18	126.9	8.5	49.8	29.1	12.6
19	286.2	6.8	36.3	45.3	11.6
20	136.8	13.7	32.0	36.5	17.8
Total	10,865.9	28.2	23.4	25.2	23.2

[a] Estimates of the number of lambs marketed by quarter are based on information received from state experiment station sheep specialists and sheep industry representatives. For more detail see [9].

number of lambs are sold in the first and third quarters. Most lambs sold in the first quarter are fed lambs, while fat lambs dominate sales in the third quarter. Because of seasonal variations in lamb prices, the marketing pattern of a particular region influences total revenue from lamb. Both regional supplies of lamb and regional feeding capacities were assumed perfectly inelastic at levels existing in 1967.

Imports

New Zealand and Australia are the major sources of fresh and frozen lamb imported into the United States. The quarterly distribution of lamb imports for 1958 to 1967 is shown in Table 5. The percentage distribution of imports by quarter shows considerable variation, but for seven of the ten years the largest quantity of imports entered during the first and second quarters. Imports averaged about 12.75 million pounds annually between 1964 and 1967.

During 1967, an estimated 68 percent of lamb imports entered the United States through ports in the Northeast (region 20), and most of the remainder entered West Coast ports (retions 1 and 2). The estimated quarterly and annual distribution of 1967 lamb imports by port of entry is presented in Table 6.

The Results

Producer costs

Lamb imports can be expected to reduce average prices received by domestic lamb producers (ceteris paribus). The reduction is not, however, uniform among regions, since the quarterly marketing pattern, retail price for

Table 5. U. S. lamb imports: Annual and quarterly distribution, 1958–1967

Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
	thousand pounds (product weight)				
1958	508	3,001	1,261	2,032	6,802
1959	1,369	2,763	1,952	3,371	9,455
1960	3,785	3,647	2,311	2,690	12,433
1961	3,865	3,943	1,940	1,192	10,940
1962	3,428	2,168	5,224	2,318	13,138
1963	6,782	4,112	3,998	4,032	18,924
1964	3,709	2,515	1,633	2,582	10,439
1965	2,319	3,319	3,876	3,025	12,539
1966	4,606	5,518	2,165	2,592	14,881
1967[a]	4,069	4,873	2,293	1,911	13,146

[a] Published data on lamb and mutton imports were combined in 1967. The 1967 lamb import data were estimated by assuming that 1966 proportions of lamb and mutton were representative of 1967 conditions.
Source: [15].

Table 6. Estimated quarterly lamb imports by port of entry, United States, 1967

Port of entry	Quarter Q_1	Q_2	Q_3	Q_4	Annual
	thousand pounds (product weight)				
Region 1	175	158	0	5	338
Region 2	801	1,596	826	645	3,868
Region 20	3,093	3,119	1,467	1,261	8,940
Total	4,069	4,873	2,293	1,911	13,146

Source: Jerry Malouf, west coast manager of New Zealand Meat Development Company, Oakland, California; and [2].

carcass lamb, average slaughter weight, dressing percentage, and marketing margin determine a region's total revenue from lamb and each of these factors varies by quarter and/or region. The extent of regional variation in the impact of imports is illustrated by data in Table 7. Regional average and total farm returns for lamb, assuming an equilibrium solution under conditions as specified, are presented for Model I (no imports). Percentage decreases in total revenue due to the level of imports in Model II and Model III are also shown in Table 5. The 1967 level of imports (Model II) resulted in a \$3.67 million (1.61 percent) decrease in total revenue. Regional decreases in total revenue ranged from 1.36 percent in region 6 to 1.85 percent in region 13. An increased level of imports (Model III) resulted in a \$7.8 million (3.43 percent) decrease from Model I equilibrium returns. Regional decreases in total revenue ranged from 2.81 percent in region 6 to 4.75 percent in region 2.

The majority of regional differences in the impact of imports on farm returns are due to two factors—the quarterly level of imports and the quarterly sales pattern of the region. The quarterly level of imports and the price elasticity of demand determine the decrease in quarterly prices. Under Model II the price impact of imports averaged 35 cents per lamb in quarter 1, 46 cents per lamb in quarter 2, 34 cents per lamb in quarter 3, and 21 cents per lamb in quarter 4. The price impact under Model III averaged 68 cents per lamb in quarter 1, 97 cents per lamb in quarter 2, 69 cents per lamb in quarter 3, and 43 cents per lamb in quarter 4. It is obvious that any region marketing a high proportion of its lamb crop in the second quarter will suffer an above-average decrease in total returns; regions marketing the

Table 7. Regional farm prices for fat and fed lamb, Model I, and percentage decreases in total revenue occurring under Model II and Model III, 1967[a]

Region	Farm price for fat-fed lambs, Model I[b]	Total revenue farm level, Model I	Decrease in total revenue: Model II	Decrease in total revenue: Model III
	dollars per lamb	*million dollars*	*percent*	
1	21.08	9.47	1.68	4.35
2	21.30	20.12	1.72	4.75
3	20.78	12.43	1.75	3.55
4	20.68	7.46	1.55	3.14
5	20.79	5.68	1.75	3.68
6	20.67	4.48	1.36	2.81
7	20.52	23.64	1.48	3.00
8	20.52	4.15	1.51	3.06
9	20.60	12.85	1.53	3.13
10	20.65	23.29	1.54	3.12
11	21.07	8.51	1.79	3.74
12	20.77	16.28	1.54	3.12
13	22.22	.64	1.85	3.87
14	21.15	12.32	1.63	3.31
15	21.00	20.11	1.62	3.28
16	21.00	13.34	1.62	3.27
17	21.30	20.75	1.63	3.34
18	21.57	2.74	1.73	3.61
19	21.66	6.20	1.70	3.51
20	21.86	2.99	1.64	3.36
Total	20.93	227.45	1.61	3.43

[a] Model I has no imports; Model II includes 13.146 million pounds of imports (1967 level); Model III has 26.292 million pounds of imports. The value of lamb imports is not included in calculating total revenue at the farm level.

[b] Values are an average of quarterly prices weighted by quantities shown in Table 4. Quarterly farm prices were calculated by multiplying retail prices by average carcass weight to obtain the value of a lamb carcass. Average carcass weights for the four quarters were 52.15, 49.39, 47.78, and 50.48 pounds. The retail value of a carcass was then multiplied by the farmer's share of the retail value to obtain farm value. The farmer's share of the retail value for the four quarters was 51, 57, 54, and 52 percent.

largest proportion of their lamb crop in the fourth quarter will incur below-average decreases in total revenue. Regions 2, 5, 11, 13, and 18 marketed over 40 percent of their lamb crop in the second quarter; and regions 6, 7, and 8 were the only regions with over 35 percent of annual sales in the fourth quarter (Table 4). The regional impact of imports, as illustrated in Table 7, could easily be changed with a different quarterly pattern of imports, i.e., imports peaking in the fourth rather than in the second quarter.

Larger than average price decreases occurred in regions 1 and 2 during the second quarter under Model III when increased imports were forced to enter these regions. Compared with an average price decrease of 97 cents, region 1 had a price decrease of $1.68 per lamb and the decrease in region 2 was $1.60 per lamb. As previously discussed, increased imports in these regions changed them from importing to exporting regions. The solutions for Models I and II in the second quarter showed region 3 shipping to region 1 and region 5 shipping to region 2. The increase in imports under Model III yielded a solution in which region 1 shipped to region 4 and region 2 shipped to regions 4 and 20. Since region 20 (the Northeast) also receives imports, one would not expect this situation to persist over time. However, this does indicate a type of short-run price impact that can result from imports.

Most of the remaining regional differential in the impact of imports can be explained by changes in optimum shipment patterns. The price impact of imports in regions 12, 13, and 18 was 26 cents per lamb; and it was 28 cents per lamb in region 19 under Model II, compared with the average of 35 cents per lamb. The solution for Model I in the first quarter had region 12 shipping to regions 13, 18, 19, and 20. With the Model II level of imports, region 12 stopped shipping to regions 19 and 20; region 11 shipped to region 18; and region 14 shipped to region 19. Prices for the Model III solution for the first quarter averaged 68 cents per lamb below Model I results. Smaller than average price decreases of 56 cents per lamb in regions 12 and 13; 59 cents per lamb in region 18; and 61 cents per lamb in region 19 were the result of changes in shipment patterns. Model I results for the first quarter are presented above. With the Model III level of imports, region 12 stopped shipping to regions 18, 19, and 20; region 11 shipped to regions 11 and 18; and region 14 shipped to region 19.

During the fourth quarter under Model III we find a price decrease of 35 cents per lamb rather than 45 cents in regions 12, 13, and 18. Under Model I and Model II, region 12 shipped to regions 13, 18, and 20. Under Model III, region 12 no longer shipped to region 20 and region 11 shipped to region 18.

The percentage impact of lamb imports on net returns is of course much higher than on total returns. A measure of the impact of Model II and Model III levels of lamb imports on estimated net returns is shown in Table 8. A dollar return to the land resource for each fat and feeder lamb produced is presented for each region for the three model situations.[15] As shown,

Table 8. Estimated regional returns to the land resource per lamb, three levels of imports, 1967 conditions

Region	Model I	Model II	Model III
	dollars per lamb[a]		
1	7.83	7.48	6.95
2	.68	.31	(.40)
3	7.52	7.16	6.80
4	5.76	5.45	5.15
5	13.71	13.30	12.84
6	8.71	8.38	8.04
7	7.74	7.42	7.09
8	8.12	7.76	7.40
9	8.70	8.39	8.07
10	5.20	4.86	4.51
11	4.70	4.32	3.91
12	12.23	11.95	11.68
13	.73	.34	(.07)
14	4.93	4.57	4.20
15	1.93	1.57	1.19
16	4.22	3.89	3.54
17	5.33	4.98	4.61
18	10.36	10.00	9.61
19	.25	(.09)	(.46)
20	(.91)[b]	(1.26)	(1.63)

[a] These figures include estimated federal shorn and unshorn wool payments, wool sales, and returns for culls. Thus, it is a net return per lamb for the total sheep enterprise. Factors such as lambing percentage, selling weight, proportion selling as fat lambs and feeders, regional feed costs, and other costs of production, including a return for management, were included in the calculations. The tabled figures can be converted to a percentage return on land investment by dividing by the investment in land required to produce one lamb.
[b] Parentheses denote a loss.
Source: [9].

there is considerable variation in net returns to land for each of the three models. For Model I, returns range from a high of $13.71 per lamb in region 5 to a loss of 91 cents per lamb in region 20. With imports, we find two regions with negative returns under Model II and four regions under Model III.

Consumer benefits

Lamb imports provide an increased supply of lamb at lower prices for consumers. Our analysis provides an estimate of these consumer benefits.

The Model II level of lamb imports increased the amount of carcass lamb available to consumers by 4.4 percent. Equilibrium quantities increased from 2.3 to 3.6 percent in regions located in the West household region (regions 1, 2, 3, 4, 5, 6, 7, and 8); from 9.5 to 14.5 percent in regions located in the North Central household region (regions 9, 10, 11, 14, 15, 16, and 17); from 10.4 to 17.9 percent in regions located in the South household region (regions 12, 13, 18, and 19); and 2.2 percent in the Northeast household region (region 20). Equilibrium retail prices for carcass lamb decreased an average 1.63 percent. There was little regional variation in price decreases, with the range being 1.52 to 1.70 percent (1.22 to 1.32 cents per pound).

The Model III level of imports increased the amount of carcass lamb available to consumers by 8.1 percent. Equilibrium quantities increased from 4.9 to 6.3 percent in regions located in the West household region; from 14.3 to 29.7 percent in regions located in the North Central household region; from 21.3 to 36.6 percent in regions located in the South household region; and 4.4 percent in the Northeast household region. Price decreases ranged from 3.2 to 4.1 percent (2.47 to 3.28 cents per pound) with an average decrease of 3.47 percent.

Some Implications

The analysis illustrates a few of the many factors that must be considered in attempting to estimate the price impact of lamb imports. The level and timing of imports, and combined with seasonal and regional characteristics of domestic supply and demand, produce pronounced regional variation in the annual price impact of imports. Quarterly marketing patterns, restricted ports of entry for imports, and changes in optimum distribution patterns account for most of the regional variation. Quarterly import quotas could be used to equalize the regional impact of imports associated with quarterly marketing patterns. For instance, with 1967 imports of 13.1 million pounds, we estimated that a distribution of 4.32 million pounds in quarter 1, 3.43 million pounds in quarter 2, 2.23 million pounds in quarter 3, and 3.14 million pounds in quarter 4 would have equalized the average quarterly impact of imports.[16] However, the increase in total industry revenue from this equalization is so small under 1967 conditions that the procedure hardly seems worthwhile.

The effect of promotional activities by domestic producers and exporters was excluded

[15] The tabled figures are a combination of land and location rents. It is impossible to separate quality and location factors, since over time locational advantages get imputed into the price of land.

[16] To allocate quarterly imports properly, the demand relationships should be reestimated with price the dependent variable. For a discussion of the allocation procedure and statistical considerations, see Waugh [17, pp. 87–91].

from the analysis. Thus, the decreases in total revenue to producers and price benefits to consumers must be considered as maximums. Even so, they were not large for the 1967 level of imports. Producers' revenue was decreased by 1.61 percent; retail prices for carcass lamb declined an average of 1.63 percent. It is clear, however, that sharply increased levels of lamb imports must be accompanied by promotional activities if domestic producers' returns are to be maintained.

Import restrictions on fresh and frozen lamb meat have been and will continue to be proposed. These restrictions could take the form of annual and/or quarterly quotas, tariffs, market sharing arrangements, and joint promotional activities by importers and domestic producers. This paper emphasizes that a number of factors must be considered in light of the stated goals of a particular proposal. Unrestricted or restricted lamb imports have regional as well as industry-wide implications.

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Research Notes

Comparative Investment per Worker in Agriculture and Manufacturing Sectors of the Economy

Allen G. Smith

Investment in production assets per farm worker in agriculture has increased 15 times since 1940 and more than doubled in the last 10 years. Substitution of capital for labor through increased mechanization of farming operations has resulted in a reduction in farm workers and increased investment in production assets. The introduction of the mechanical cotton harvester is an outstanding instance of the substitution of capital for labor, along with grain combines, corn pickers, potato harvesters, and fruit pickers.

How does investment per worker in agriculture compare with investment per worker in the manufacturing industry? Generally, the comparison is made between asset data from the *Balance Sheet of the Farming Sector* for agriculture and data from the *Quarterly Report of Manufacturing Firms* for manufacturing. Assets are not valued the same way, however, for these two reports. Agricultural assets are valued on a current basis—that is, essentially, an inventory of physical units is multiplied by the current market value per unit. Assets for manufacturing enterprises, on the other hand, are compiled from financial statements of manufacturing firms and are generally values based on cost less capital consumption (depreciation plus other capital disappearance allowances). In inflationary periods, especially, the two values are not comparable.

A second problem in comparing agriculture with manufacturing is the definition of a production worker. Most farms combine labor and management in one individual, with one or two additional hired workers. In manufacturing, management and labor are generally separated. For example, the average employment in manufacturing during 1968 was 19.7 million persons, but production workers numbered only 14.5 million.

Using average number of total farm workers, including both self-employed and hired, and average number of production workers only for manufacturing, average investment per farm worker was $50,020; per production worker in manufacturing enterprises, $35,222. Using this approach, the investment per worker on farms is almost one and one-half times as much as in manufacturing enterprises. The investment per employee, including both production and management, in manufacturing enterprises is $25,846; on this basis, agriculture's investment is almost twice that of manufacturing.

In the 1969 *Balance Sheet of the Farming Sector* assets in farming on a cost basis were estimated to be $136.9 billion, or $28,833 per farm worker. The cost basis is more comparable to the book value of manufacturing firms than current values. Depreciable assets are usually carried on manufacturing firm balance sheets at cost less depreciation. Nondepreciable items, such as land (the largest value item in agriculture but relatively minor in manufacturing), are shown at cost.

The value of land has appreciated rapidly in recent years. This land appreciation, combined with a declining number of farm workers, has tended to increase the value of production assets per worker very rapidly when calculated on a current value basis. The cost basis, therefore, appears to be more comparable to book value than current value basis.

All workers in both agriculture and manufacturing should be included in estimating investment per worker. With all workers in-

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cluded and with farming assets valued on a cost basis, investment per farm worker in 1969 was \$28,833 as against \$25,846 per worker in manufacturing enterprises. Investment per worker, on this basis, still appears to be higher in agriculture than in manufacturing, but only by about 10 percent, not 50 to 100 percent.

Consequently, data that are often interpreted as indicating a relatively large and rapidly rising capital/labor ratio in farming are reflecting mainly the combined effect of rising land values and a declining number of farm workers.

Nonfarm Income Earned by Commercial Farm Operators in Central Illinois*

R. J. Hanson

A study for the United States was reported by Reinsel on the amount of income received from various sources by individuals who derive some of their income from farming [2, p. 2]. That study indicated several national trends in nonfarm income and provided further detail to estimates published by ERS annually in *Farm Income Situation*. Yet there is a need for further information concerning the nonfarm income earned by farmers, especially commercial farm operators.

The purpose of this study was to determine the amounts and sources of nonfarm income earned by commercial farm operators in central Illinois. Total nonfarm income and amount by source were compared at different levels of farm and family earnings, age, and education; the various off-farm occupations of farm operators and farm wives were determined; and differences in the characteristics of farm operations were analyzed for farm operators who received wage and salary incomes and those who did not.

Off-farm employment can supplement farm income, perhaps covering occasional farm income losses, and can also stabilize total family income. Nonfarm jobs might change the structure of farming, as for example by replacing part or all of the livestock in some farm operations.

The Sample and the Data

Information for this study came primarily from 1968 cooperators in the Illinois Farm Business Farm Management Association, whose records provided farm and nonfarm income amounts for each operator. Questionnaires completed by farm management fieldmen in the study area furnished supplementary data, including the off-farm occupation of farm operator or his wife or both, place of employment, educational level, and age of farm operator.

The sample involved 299 commercial farm operators for a seven-county area in the southwest portion of central Illinois,[1] which represented 2.27 million acres and a 1968 population of 277 thousand. Springfield (population 89,816) is the only metropolitan city within the study area. Peoria (population 125,736) is 22 miles north of the study area.[2]

The sample area, generally considered a cash grain and livestock producing area, included farm operators on Class I, II, and III farms. Landlords were excluded, as were operators who were both farmers and landlords.

Empirical Findings

Nonfarm income comprised about 20 percent of the total realized income earned by all farm operators. Sources of this income are given in Table 1. All but one farm operator in the study reported some source of nonfarm income. One of every six operators reported a nonfarm income greater than his realized net farm income. The majority of farm operators reported several different sources of nonfarm income.

The farm operators in this study had an average total realized income of $11,187, of which $2,306 (about 20 percent) was nonfarm income.

Wage and salary income

Off-farm employment of farm wives was the leading source of both wage and salary income

Table 1. Nonfarm income from different sources as a percentage of total nonfarm income

Sources	Southwest Central Illinois 1968	National averages[a] 1963
	percent	
Wage and salary	61	65
Interest	9	7
Dividends	6	8
Nonfarm business	11	14
Other	13[b]	6

[a] Source: [3].

[b] Miscellaneous income, 9 percent; pensions, .3 percent; trusts, 3.2 percent; rent, .3 percent; royalties, .2 percent. This breakdown was not available from the 1963 national study.

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[1] Including Sangamon, Logan, Cass, Morgan, Mason, Scott, and Menard counties. Sangamon County was classified as metropolitan.

[2] Preliminary 1970 census population figures.

Table 2. Number and average wage and salary income of farm operators and farm wives reporting selected off-farm occupations, central Illinois study, 1968

Off-farm occupation	Number	Average wage and salary income
		dollars
Farm operators		
Businessman	8	8,370
Insurance agent	5	1,771
Seed corn salesman	27	654
Labor employee	6	2,853
School bus driver	3	2,723
Rural mail carrier	3	2,628
Farm wives		
Bookkeeper	4	1,425
Office worker	9	1,658
Teacher	16	6,931
Substitute teacher	9	1,328
Nurse	9	5,277
Secretary	6	4,284
Cook	4	2,089

and total nonfarm income. One of every four wives had nonfarm employment, and these accounted for 72 percent of the total wage and salary income and 44 percent of the total nonfarm income.

The average wage and salary income earned by farm wives working off the farm was $4,216. Most working farm wives held full-time jobs that required special skills or advanced education such as teaching, nursing, and secretarial work (Table 2). Families in which the farm wife was working outside the home had fewer children (1.96) than families in which the wife was not working (2.25).

Farm operators working off the farm earned 28 percent of the total wage and salary income and only 17 percent of the total nonfarm income. Most of them held part-time jobs off the farm, as suggested in Table 2, and their average wage and salary income was $1,405.

Farm operators who reported $2,000 or more from wages and salaries, whether earned by himself or his wife, accounted for 90 percent of the total wage and salary income and comprised 21 percent of all farm operators. This group had an average wage and salary income of $5,942. Farms for this group tended to have smaller acreages and fewer livestock than farms in which no wage and salary income was reported.

Relation of nonfarm income to operator characteristics

Farm and family earnings.—Total nonfarm income and wage and salary income decreased as farm and family earnings increased. Farm and family earnings are defined as the value of farm production less cash operating expenses and depreciation [1, p. 13]. Farm operators with negative farm and family earnings (−$389) nevertheless received a total realized income of $3,837, because of their off-farm earnings. Average nonfarm income was $4,226 for these operators; only $815 for operators with farm and family earnings of $20,000 or more.

Nonfarm income was a smaller percentage of the total realized income for operators with higher farm and family earnings. On the other hand, income received from interest plus dividends was a larger proportion of the total nonfarm income as farm and family earnings increased, and wage and salary income was a smaller percentage.

Age of operator.—Total nonfarm income, wage and salary income, and the proportion of the total realized income accounted for by nonfarm income increased with age of farm operator up to 61 years or older (Table 3). Farm operators under 41 years of age reported the lowest levels of nonfarm income; those between 51 and 60 received the largest amounts of wage and salary income, nonfarm business income, and interest.

Education of operator.—Total nonfarm income and wage and salary income increased with higher education levels of farm operators. In contrast, there were no significant increases in farm income for different levels of education, as suggested in Table 4. Nonfarm income comprised 10 percent of the total realized income for farm operators with grade school education;

Table 3. Farm and nonfarm income averages of farm operators by age classifications

	Age (years)				
	20–30	31–40	41–50	51–60	61 and over
			dollars		
Total realized income	8,990	8,690	11,846	14,714	8,869
Total realized net farm income	7,944	7,615	9,434	10,342	6,967
Total nonfarm income	1,046	1,075	2,412	4,372	1,902
Wage and salary	593	793	1,694	1,905	1,104
Nonfarm business	0	15	105	1,183	0
Dividends	35	33	201	157	96
Interest	49	82	206	390	387
Rental	0	11	10	−9	3
Miscellaneous	209	109	192	364	212
Royalties	0	2	1	3	34
Trusts	161	30	3	361	28
Pensions	0	0	0	16	38

52 percent for operators with college degrees.

Farm operators with college educations received an average nonfarm income ($7,071) that was greater than their average realized net farm income ($6,498). Besides earning the highest wage and salary income, operators with college degrees also acquired the highest nonfarm business income, interest, and dividends.

Farm wives whose husbands had college degees had an average off-farm income of $1,082, which accounted for 15 percent of the total nonfarm income reported by their husbands (see Table 4). In contrast, wives whose husbands had some college training earned 63 percent ($1,765) of the total family nonfarm income, while wives of husbands with just high school education contributed 55 percent ($1,097) to their total family nonfarm income. These data, on the surface, do not appear to support the general notion that going through college is correlated with acquiring a well-educated and therefore highly employable wife. For those farm operators with grade school education, none of the wives received off-farm income. This combination of findings, for operators with college degrees compared with those with only high school or grade school education, is compatible. Whether a farmer's wife is employed for wages or salary depends on both ability and desire to adopt this course of action. The wife of a farm operator who has a college degree may have the ability to obtain remunerative employment but for a variety of reasons may choose not to do so.

Table 4. Farm and nonfarm income averages of farm operators by levels of education

	Grade school	Some high school	High school completed	Some college	College degree
			dollars		
Total realized income	7,137	7,381	11,479	9,893	13,569
Total realized net farm income	6,431	6,091	9,486	7,085	6,498
Total nonfarm income	706	1,290	1,993	2,808	7,071
Wage and salary	8	724	1,355	2,409	2,593
Nonfarm business	0	0	76	0	2,649
Dividends	39	107	111	85	543
Interest	493	129	198	87	383
Rental	0	0	7	0	13
Miscellaneous	9	285	172	226	597
Royalties	73	0	1	0	0
Trusts	0	44	73	0	266
Pensions	83	0	1	0	26

Conclusions

Although this study consisted entirely of commercial farm operators, some of these operators have successfully combined off-farm employment with their farm operation. It may be that improving capabilities for handling larger volumes allow farm operators to combine part-time nonfarm employment with their commercial farm operations. Furthermore, in this era of a rapidly changing structure in farming, off-farm employment could be a variable affecting the direction and rapidity of this change, such as replacing part or all of the livestock in some farm operations.

The ability of commercial farm operators, as well as other farmers, to continue farming while also holding off-farm employment has important implications for the farm-business organization, public-policy considerations, and resource allocations within agriculture. Nonfarm income may be quite important, even for commercial farm operators, in closing the income gap between farm and nonfarm workers.

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Feed Formulation For Least Cost of Gain

J. A. McDonough

The conventional least-cost ration criterion for feed blending will not necessarily result in the cheapest ration overall. Lofgreen [1] has shown that an animal's "maintenance energy" requirement must be met before food energy can be converted to production. He has evaluated the effectiveness of the food energy content of various feedstuffs for use in maintenance (NE_m content) as well as their effectiveness towards production (NE_p). It is the interaction of these two "effectiveness factors" that usually prevents a minimum-cost ration from being the optimal overall solution unless provisions are made to take these factors into account. This paper derives an *LP* method for solving for the least cost of gain ration.

A property of any given feed mixture that meets other nutritional requirements on protein content, fiber, vitamins, etc., is the cost per pound of gain that would be achieved if the ration were fed. This very important property of the ration may be estimated by using Lofgreen's concepts. Consider an average animal of a given weight and type (a 600-pound steer, for example). Lofgreen's tables or their generating equations [2] may then be consulted and the maintenance requirements extracted from them (5.21 Mcal. per day). The other data required would be the additional "production energy" intake equivalent to a pound of gain at the expected performance level. For example, if gain will be in the neighborhood of 3.0 pounds, the energy equivalent of a pound of gain is 5.64/3 or 1.88 Mcal. per pound. Finally, we must establish how much feed the animal will consume daily. For simplicity, 0.25 percent (on a dry basis) of the animal's weight is used here, but any equation predicting feed consumption (such as those in the cattle simulator developed by Dr. Meredith Smith of IBM) could be used. This is an important consideration as an examination of the gain cost equation (5) shows that the amount that an animal will eat is a very large factor in determining the optimum ration.

Now consider any general feeding specification, as supplied by a nutritionist, that will formulate a palatable ration with a balanced nutritional content (i.e., specifications of the desired percentage limits or ranges on protein, fiber, supplement, etc.). Note that we are not discussing a set of rations that vary slightly in (say) NE_p content. The development here will formulate the absolute minimum gain cost ration, not merely select the one with the least gain cost from a set of rations.

For maintenance, the animal will use the following pounds per day of feed, assuming an environment where thermo-neutrality is possible:

$$(1)\quad 5.21/NE_m = \text{pounds of feed used for maintenance.}$$

The balance of the ration consumed will provide energy that is usable for production. (Consumption basis is 15 pounds dry or $15/D$ on an as-is basis.)

$$(2)\qquad (15/D - 5.21/NE_m)NE_p = E_g$$

The daily gain may then be computed using the Lofgreen production energy equivalence constant.

$$(3)\qquad E_g/1.88 = g$$

The total cost per day of the ration is

$$(4)\quad (15/D)C = \text{total cost of feed per day}$$

Division yields the daily cost per pound of gain, G_c:

$$(5)\quad G_c = \frac{C\cdot 15/D}{(15/D - 5.21/NE_m)\cdot NE_p/1.88}$$

Defining the constants $A_1 = 1.88$ and $A_2 = 5.21/15.0$, the gain cost, G_c, of a ration may then be written as

$$(5)\qquad G_c = \frac{A_1 C/NE_p}{1 - A_2 D/NE_m}$$

or in expanded form

$$(5)\qquad G_c = \frac{A_1(\sum C_i X_i)/(\sum E_i X_i)}{1 - A_2(\sum D_i X_i)/(\sum M_i X_i)}$$

Now consider the definition of the derivative of G_c:

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$$(6)\qquad \begin{aligned} dG_c &= \frac{\partial G_2}{\partial X_1}\,dX_i + \frac{\partial G_c}{\partial X_2}\,dX_2 + \cdots \\ &= \sum \frac{\partial G_c}{\partial X_i}\,dX_i \end{aligned}$$

These $\partial G_c/\partial X_i$ are calculable but are exact only for the set of X_i from which they are derived. However, they are good approximations if the composition of the mixture is not changed radically and may be used to compute the change in the cost of gain resulting from a change in the values of the X_i in the following manner.

Applying finite difference notation, equation (6) may be written as a difference equation:

$$(7)\qquad \Delta G_c = \sum \frac{\partial G_c}{\partial X_i}\,\Delta X_i = \sum Z_i \Delta X_i$$

and since a difference for any variable, V, may be defined as $\Delta V = V_{new} - V_{old}$, we may write

$$(8)\qquad \begin{aligned} &(G_c)_{new} - (G_c)_{old} \\ &\qquad = \sum Z_i(X_i)_{new} - \sum Z_i(X_i)_{old} \end{aligned}$$

Since $(G_c)_{old}$ and $Z_i(X_i)_{old}$ are constant, the minimization of $\sum Z_i(X_i)_{new}$ would minimize G_c. Thus, if the Z_i are substituted for the cost coefficients in a linear programming formulation, we may solve for a new set of X_i (the ration composition vector); and this new ration will be a closer approximation of the least gain cost ration. The rigor of the technique is defensible only if the changes in composition are small, but repeated iterations have never failed to converge to a unique solution.

If the daily gain, g, is relatively constant (i.e., energy content of the ration has been constrained by the nutritionist), we may use the following analytic equation to evaluate the Z_i:

$$(9)\qquad \begin{aligned} Z_i &= \frac{G_c C_i}{C} - \frac{G_c E_i}{NE_p} + \frac{A_2 G_c}{1 - A_2 D/NE_m} \\ &\quad \cdot \left(\frac{D_i}{NE_m} - \frac{DM_i}{NE_m{}^2}\right). \end{aligned}$$

However, a good general method suitable for computer use is to compute Z_i by finite difference methods:

A step-by-step method for formulating the least cost of gain ration follows:

1. Determine size of animal (average), expected consumption, NE_m requirement, and evaluate coefficient A_2.
2. Utilizing the LP model that contains all nutritional and palatability limitations on protein, fiber, minerals, vitamins, supplement, etc., that is supplied by the nutritionist, solve for the least cost of feed ration.
3. Utilizing the resultant set of X_i, solve for the NE_m and NE_p content of the new ration. Then obtain the daily gain and reevaluate A_1. Finally, solve for the gain cost, G_c, (equations (2), (3), (4), (5)).
4. Using the set of X_i obtained from the LP, solve for the Z_i for *all* major ingredients available (equation (9) or (10)). Note that all ingredients must be treated, as it is not unlikely for an ingredient to be pulled back into the least gain cost solution where it was driven to zero level in the least feed cost solution.
5. Using the set of Z_i as costs, re-solve the LP and get a new set of ingredient levels, X_i.
6. Repeat step 3 and 4 using the latest set of X_i. When the Z_i do not change appreciably, the solution has been obtained.

It is usually not necessary to repeat the LP more than once, especially if a reasonably close first guess of the optimum composition vector is made. In fact, if only a few ingredients are available, the least cost of feed solution is likely to be the least gain cost solution also. In general, this method requires much less computer time than other methods that involve multiple LP solutions.

The mathematical development has assumed A_1 to be nearly constant. This is usually the case where the nutritionist has specified the energy content of the ration within narrow limits as this effectively fixes the rate of gain. However, in the general case, we may utilize Lofgreen's generating equation:

$$(11)\qquad A_1 = B_1 + B_2 g$$

Then, using equation (3), we may write an equation for A_1 in terms of E_g.

$$(12)\qquad A_1 = 0.5(B_1 + \sqrt{B_1{}^2 + 4B_2E_g})$$

Substituting this into the gain cost equation

$$(10)\qquad Z_i = \frac{G_c(X_1, X_2, \cdots, X_i + 0.01, \cdots) - G_c(X_1, X_2, \cdots, X_i \cdots)}{0.01}.$$

yields

$$(13) \quad G_o = \frac{0.5C(B_1 + \sqrt{B_1^2 + 4B_2E_g})}{(1 - A_2D/NE_m)NE_p}$$

This equation may be used to develop the Z_i for a completely general solution.

The technique is by no means limited to this use in feeding cattle and could be extended to (say) maximizing dairy production or swine production. The only requirement is that the optimum sought be capable of being expressed as a function of the ingredient level, as is the cost of gain, G_o.

Definitions of Terms

- X_i Proportion of feedstuff I in a ration expressed as a fraction.
- NE_p Net energy usable for production for a given ration or blend (Mcal. per pound).*
- NE_m Net energy for maintenance available from a given ration (Mcal. per pound).*
- G_o Gain cost (dollars per pound of production).
- E_i NE_p of feedstuff$_i$, (Mcal. per pound).*
- M_i NE_m of feedstuff$_i$, (Mcal. per pound).*
- D Dry matter fraction of a ration.
- D_i Fraction of dry matter in feedstuff$_i$.
- C Unit cost of a finished ration (dollars per pound).
- C_i Unit cost of feedstuff$_i$ (dollars per pound).
- Z_i $\partial G_o/\partial X_i$ = partial derivative of the gain cost with respect to a change in feedstuff$_i$.
- A_1 The average energy required for production, Mcal. per pound gained.
- A_2 A constant used to simplify the equations; equal to the daily maintenance energy requirement of an animal divided by 15.
- W Animal weight (pounds).
- g Daily gain in weight (pounds).
- E_g Energy available for gain (Mcal).
- B_1 Constant (600-pound steers only) $= 0.013225\ W^{.75} = 1.604$.
- B_2 Constant (600-pound steers only) $= 0.000778\ W^{.75} = 0.094$.

* Tabulated values are commonly given in Mcal. per 100 pounds on a 90 percent dry basis, but these equations are derived on an as-is basis.

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A Note on the Definition of the Economic Region of the Production Function*

RICHARD S. JOHNSTON AND A. GENE NELSON

SEAGRAVES AND PASOUR (hereafter S-P) offer a strong argument for accepting a cost-oriented definition of the "uneconomic regions" of the production function in the theory of the firm [3]. We hope in this note to make a few amendments to the S-P argument and, in so doing, to cast further doubt on the usefulness of the traditional "stages of production" notion as a pedagogical device.

To illustrate the problems with conventional definitions of "economic region," S-P have employed a homogeneous production function. They also, implicitly at least, assumed the "fixed factor" to be perfectly divisible.[1] We shall argue that:

1. In the case of a two-input production function, when one input is *fixed* and ***indivisible***, the firm facing constant input and product prices will choose not to produce if output price falls below average variable costs. The reason for this is *not* that the marginal physical productivity of the "fixed input" is zero at the output corresponding to minimum average variable costs (this is true, however, for linear and homogeneous production functions), but rather that if the firm produces when product price is less than average variable costs, it will earn a negative quasi-rent. For some functions, the marginal physical productivity of the "fixed factor" may be negative at the minimum average variable cost output. The firm may wish to employ fewer units of that factor but is unable to do so because of its indivisible nature. Thus, production where the marginal physical productivity of an input is negative need not imply "uneconomic" production.

2. In the case of a two-input production function, when one input is *fixed* but ***divisible***, the firm facing constant input and product prices will combine inputs so that the marginal physical productivities of both inputs are nonnegative.

Thus, we shall recommend that discussion of production stages as traditionally presented should be either dropped from textbooks on microeconomic theory or amended to include explicit specifications on

(a) the nature of the production function;
(b) the nature of the factor fixity;
(c) product and factor price relationships.

To begin, we shall retain the production function employed by S-P and, with them, assume constant product and factor prices. Thus we satisfy our own criteria (a) and (c).[2] Their production function is

$$y = \frac{x_1^2x_2 - 0.1x_1^3}{x_2^{\alpha}} \tag{1}$$

which is homogeneous of degree $(3-\alpha)$ in x_1 and x_2. S-P considered three cases: $\alpha=2$, $\alpha=1.5$, and $\alpha=2.5$, in order to examine the technical relationships between x_1 and x_2 when the production function is homogeneous of degree one, greater than one, and less than one, respectively. Setting $x_2=1$ yields the short-run product curve

$$y = x_1^2 - 0.1x_1^3 \tag{2}$$

which holds irrespective of the value of α [3, p. 196].

Following an argument advanced by Mundlak [2], S-P show that, for homogeneous production functions in x_1 and x_2, when the marginal physical productivity of x_2 ($MPPx_2$) is negative, the ratio of the marginal physical productivity of x_1 ($MPPx_1$) to the average physical productivity of x_1 ($APPx_1$) must be greater than the degree of homogeneity of the function. Thus, only for linear and homogeneous production functions does the value of x_1 for which $APPx_1$ is maximum correspond to the value of x_1 for which $MPPx_2=0$, since at the maximum value of $APPx_1$, $APPx_1=MPPx_1$. If the degree of homogeneity is less than one (as when $\alpha=1.5$),

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[1] This note was prepared prior to the publication of John M. Gates' comment in this Journal [1], in which he does distinguish divisible from indivisible "fixed" factors in discussing the economic region of production. This paper analyzes some implications of this important distinction.

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[2] Although we have yet to specify what these prices are.

the $MPPx_2$ becomes negative at a smaller value of x_1 than where $APPx_1$ is a maximum.

S-P argue persuasively that "... if it pays to use any x_1 at all, it pays to use it at or beyond the point where $APPx_1$ is maximum (and hence average variable cost increasing in the single variable input case)." S-P conclude from this that "*the economic region of production is defined by a decreasing $APPx_i$ and a positive $MPPx_i$ for each input, x_i, while every other input is assumed to be constant*" [3, p. 198]. We feel this to be an unfortunate extension since, by implication, it states that production in any other region is "uneconomic." We submit that a firm with one or more inputs constant, i.e., fixed and indivisible, will operate as long as its short-run variable costs are covered. Whether the marginal physical productivity of a fixed input is positive becomes irrelevant. This is true no matter what the production function in x_1 and x_2 is. Thus, if the short-run product curve is represented by equation (2), the firm will hire five or more units of x_1.[3]

Notice that the nature of the short-run fixed factor has now been specified, in accordance with criterion (b). The argument of the preceding paragraph rests on the assumption that the meaning of $x_2=1$ is that no matter how many units of x_1 are used in producing y, exactly one unit of x_1 is both *used* and *paid for.* Again, presumably x_2 is an indivisible input.

Consider the case where $\alpha=2.5$, so that the degree of homogeneity (and hence the elasticity of production) is .5. S-P argue that since the $MPPx_2=0$ at $x_1/x_2=6$ and is negative where $(x_1/x_2)<6$, the firm would never produce where $(x_1/x_2)<6$.[4] Since $x_2=1$, this means the firm would never hire fewer than six units of x_1. This appears to contradict our earlier finding that the firm would hire five or more units of x_1. If the firm in fact hired five units of x_1, it would appear to be operating uneconomically, by the S-P definition, since $MPPx_2<0$ at $x_1=5$.

[3] $$\frac{y}{x_1}=\frac{x_1^2-0.1x_1^3}{x_1}=x_1-0.1x_1^2;$$
$$\frac{d\left(\frac{y}{x_1}\right)}{dx_1}=1-.2x_1 \quad \text{which} = 0 \text{ when } x_1=5.$$

[4] $$y=[x_1^2x_2-0.1x_1^3]x_2^{-2.5};$$
$$\frac{\partial y}{\partial x_2}=\frac{x_1^2}{x_2^{2.5}}-2.5\frac{[x_1^2x_2-0.1x_1^3]}{x_2^{3.5}}=0 \text{ at maximum.}$$

Given $x_2=1$, $x_1^2-2.5x_1^2+.25x_1^3=0$ which, on solution, gives $x_1=6$.

The difficulty here lies in the meaning of the assumption that $x_2=1$. If the firm must in fact employ one full unit of x_2 (the classic example here is the roadbed of a railroad), the price of y could well be low enough that the firm would employ only five units of x_1. For example, if $Px_1=\$10$ and $Py=\$4$, the firm will employ five units of x_1, produce 12.5 units of y, and earn zero quasi-rent. Of course the firm would in this case prefer to dispose of part of x_2. However, our interpretation of the assumption $x_2=1$ precludes this possibility. On the other hand, if the firm were to combine six units of x_1 with the single unit of x_2 at these prices, it would lose \$2.40.

Suppose that $x_2=1$ were changed to mean that the firm had to *pay* for the services of one full unit of x_2 but that not the entire unit of x_2 had to be employed in the manufacture of y. Here then is a different specification on the nature of "fixity." Notice that the situation is still "short run" in nature, since (a) the firm can hire no more than one unit of x_2 and (b) exactly one unit of x_2 must be paid for. The problem is a constrained profit-maximization problem of the form:

Maximize

$$(3) \qquad Py\cdot y-P_1x_1-P_2x_2$$

subject to

$$(4) \qquad (a) \quad y=\frac{x_1^2x_2-0.1x_1^3}{x_2^{2.5}}$$

and

$$(5) \qquad (b) \quad x_2\leq 1.$$

Notice that P_2x_2 is a "fixed cost" equal to $P_2\cdot 1$, since one unit of x_2 must be paid for whether used in production or not. What is the smallest quantity of x_1 that the firm would ever hire in this situation?

We submit that this question can be answered correctly only in the knowledge of Py and Px_1, as per specification (c) in our earlier list. Since one unit of x_2 must be paid for, the marginal factor cost of $x_2=0$ for $x_2\leq 1$ and $=\infty$ for $x_2>1$. Thus, from the short-run profit-maximizing conditions,

$$(6) \qquad Px_2=PyMPPx_2$$

and

$$(7) \qquad Px_1=PyMPPx_1,$$

we have

$$MPPx_2 = 0$$

and

(6a) $$Px_1 = PyMPPx_1$$

as the conditions to be satisfied.

From our earlier example, in which $Px_1=10$ and $Py=4$, $MPPx_2=0$ when

(6b) $$\frac{x_1^2}{x_2^{2.5}} = \frac{2.5[x_1^2x_2 - 0.1x_1^3]^5}{x_2^{3.5}}$$

i.e., when

(6c) $$x_1^2 = \frac{2.5x_1^2x_2 - 0.1x_1^3}{x_2},$$

which reduces to

(6d) $$x_1 = 6x_2.$$

This is precisely the condition that S-P defined as the beginning of the "economic region of production"; i.e., $x_1/x_2=6$.

With $Px_1=10$ and $Py=4$, condition (7) is

(7a) $$10 = 4\frac{[2x_2x_1 - 0.3x_1^2]}{x_2^{2.5}}$$

Solving (6d) and (7a) simultaneously yields

$$x_2 = .2304$$
$$x_1 = 1.3824$$
$$y = 6.912$$

Here quasi-rent

$$= 4(6.912) - 10(1.3824)$$
$$= 13.824$$
$$> 0.$$

Thus, the firm has reduced its employment of both x_1 and x_2 in the production of y, although it continues to pay $Px_2 \cdot 1$ for x_2.

[5] See footnote 4.

It is important to note that, unless $Px_2=0$, the point (.2304, 1.3824) is *not* on the expansion path for this firm. It is, in fact, on the ridge line corresponding to $MPPx_2=0$. The value of x_1 corresponding to $x_2=1$ on the expansion path depends on the price of x_2 but, of course, must exceed 6.[6] If the firm is forced to use one unit of x_2 in production, it would remain in production in the short run for values of $x_1 \geq 5$, as previously argued.[7] If the firm, although having to pay for one unit of x_2, can reduce the use of x_2 in the production of y, it will locate on the ridge line,[8] the location depending upon Px_1 and Py. In our earlier example, this point is (.2301, 1.3824). The point is that for this particular production function, and on the assumption of divisible fixed and variable factors, one can assign market prices to y and x_1 so that any amount of x_1 may be hired economically, as long as $MPPx_1>0$. To discuss regions of production solely in terms of production relationships, therefore, is misleading.

In the case of this particular homogeneous function, the ridge line corresponding to $MPPx_2=0$ has the equation $x_1=6x_2$; i.e., it is linear. Thus, one can interpret S-P's Figure 3 [2, p. 200] as appropriate as long as one recognizes that the horizontal axis measures the ratio x_1/x_2, where $x_2 \leq 1$. One should not interpret their figure as saying that if $x_2 \leq 1$ the rational producer will hire at least six units of x_1.

Thus we conclude with a plea for abandoning the traditional definitions of economic and uneconomic regions of production. We submit that what is economic depends on the nature of the production function, the nature of the factor inputs, and the nature of market prices.

[6] For this particular function, the "long-run" total cost curve has a shape such that for any $Py>0$ the firm will always choose to remain in business in the long run.

[7] We recognize that the firm would not hire units of x_1 beyond the point at which $MPPx_1=0$.

[8] This argument actually deals with the case of a "divisible and adaptable" plant, as discussed by Stigler in [4].

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On the Measurement of Price Elasticity of Demand

S. H. LOGAN, G. C. RAUSSER, AND R. A. OLIVEIRA

K. T. MURPHY [2] extends the method of measuring arc elasticity of demand presented by Lyon and Simon [1], but his approach has some apparent inconsistencies and employs incorrect procedures.

The initial formulation used to estimate arc elasticity of demand for cigarettes by Lyon and Simon is

$$e_p = \frac{\dfrac{Q_2 - Q_1}{Q_1} - \sum^{N}\left(\dfrac{Q_4 - Q_3}{Q_3}\right)\Big/ N}{\dfrac{P_2 - P_1}{P_1}}$$

where

e_p = price elasticity;
Q_1 = consumption for the year ended before price change in the trial state;
Q_2 = consumption for the year beginning after price change in the trial state;
Q_3 = consumption in the comparison states for the year before the price change in the trial state;
Q_4 = consumption in the comparison states for the year beginning after the price change in the trial state;
P_1 = price for the year before change in the trial state;
P_2 = price for the year after change in the trial state;
N = number of comparison states.

The model was applied to data involving price and quantity changes for cigarettes in a particular state. The term

$$\sum^{N}\left(\frac{Q_4 - Q_3}{Q_3}\right)\Big/ N$$

is subtracted from the numerator in order to eliminate the effect of secular changes in quantity demanded and thus permit factoring out the effect of a price change. The subtracted term represents the average percentage quantity change for other states in which prices remained constant. Thus, the assumption is that secular changes (in percentages) in the trial state are equal to the expected (average) value of secular changes in the comparison states.

Murphy comments, "Subtracting $(Q_3-Q_4)/Q_4$ in the 'control' cities implies the authors had in mind an additive model, but nowhere do they indicate they have considered this question. A model linear in logs might seem more reasonable for cigarette demand; if so, this would suggest dividing by $(Q_4-Q_3)/Q_3$—not subtracting. The latter could produce significantly biased estimates of elasticity." While Murphy's two ratios show different ordering of the subscripts, we shall assume he meant the latter ratio since it is the one used by Lyon and Simon.

Murphy also presents the following example in which the demand for cigarettes is postulated as a Cobb-Douglas function of price and disposable personal income:

$$q = a_0 P^{a_1} E^{a_2}$$

where $a_0 = a_2 = 1$, and $a_1 = -1$. Therefore e_p, the price elasticity, equals -1. The points for measurement of the arc elasticity are

Time	"Test" city			"Control" cities (average)		
	q	p	E	q	P	E
1	1	1	1	1	1	1
2	1.32	.833	1.10	1.10	1	1.10

Following Lyon and Simon's derivation, Murphy estimates the arc elasticity as

$$\frac{.32 - .10}{-.167} = -1.32,$$

which represents a difference of .32 from the true point elasticity of -1. He then states, "The bias would be reduced to 20 percent if we *divide* $(\Delta q/q)_T$ by $(\Delta q/q)_c$."[1] However, using Murphy's figures and his outlined procedure,

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[1] In Murphy's notation $(\Delta q/q)_T = (Q_2 - Q_1)/Q_1$ and

$$(\Delta q/q)_C = \sum^{N} \frac{(Q_4 - Q_3)/Q_3}{N}.$$

in no way can we duplicate an arc elasticity figure that varies from the *point* elasticity by 20 percent. In short,

$$\frac{.32/.10}{-.167} = -19.2.$$

Murphy's suggestion that secular changes should be eliminated by division for a multiplicative function is correct; however, the procedure he outlines is wrong.

Consider first the simple linear relationship:

$$q_t^r = a_{0t}^r + b_t^r P_t^r + \sum_{i=1}^{M} a_{it}^r X_{it}^r$$

where

q = quantity demanded
P = price of the commodity
X = all other predetermined variables, e.g., income, price of substitutes, etc.
t = time period 1 and 2
r = states, 1, 2, $\cdots$, N where state 1 is the trial state.[3]

The basic assumptions of the Lyon and Simon model are:

(1) $b_1^r = b_2^r$ for all r;

(2) $P_1^r = P_2^r$ for $r = 2, 3 \cdots N$ (price changes only in region 1); and

(3)
$$\frac{\Delta(a_{0t}^1 + \sum_{i=1}^{M} a_{it}^1 X_{it}^1)}{a_{01}^1 + b_1^1 P_1^1 + \sum_{i=1}^{M} a_{i1}^1 X_{i1}^1} = \frac{\sum_{r=2}^{N} \dfrac{\Delta(a_{0t}^r + \sum_{i=1}^{M} a_{it}^r X_{it}^r)}{a_{01}^r + b_1^r P_1^r + \sum_{i=1}^{M} a_{i1}^r X_{i1}^r}}{N-1}$$

while 1 = the trial state and r = all others $(2 \cdots N)$.

If we let

$$\sum_{i=1}^{M} a_{it}^r X_{it}^r = A_t^r,$$

we can write the arc elasticity as follows:

[3] This notation is a change from that employed by Lyon and Simon in that N now represents the total number of states, both trial and comparison.

unadjusted

$$e_p^1 = \frac{\dfrac{q_2^1 - q_1^1}{q_1^1}}{\dfrac{P_2^1 - P_1^1}{P_1^1}} = \frac{\dfrac{[a_{02}^1 + b_2^1 P_2^1 + A_2^1] - [a_{01}^1 + b_1^1 P_1^1 + A_1^1]}{q_1^1}}{\dfrac{P_2^1 - P_1^1}{P_1^1}}$$

Since from assumption (1) $b_1^r = b_2^r$,

unadjusted

$$e_p^1 = \frac{\dfrac{b_2^1(P_2^1 - P_1^1)}{q_1^1} + \dfrac{(a_{02}^1 + A_2^1) - (a_{01}^1 + A_1^1)}{q_1^1}}{\dfrac{P_2^1 - P_1^1}{P_1^1}}$$

The first term of the numerator indicates the change in quantity demanded resulting from the change in price, the effect we are seeking. The term on the right represents changes in quantity demanded resulting from changes in other predetermined variables. Using assumptions (2) and (3),

$$\frac{(a_{02}^1 + A_2^1) - (a_{01}^1 + A_1^1)}{q_1^1} = \frac{\sum_{r=2}^{N} \left(\dfrac{q_2^r - q_1^r}{q_1^r} \right)}{N-1}.$$

Thus, in order to eliminate the non-own-price factors from the basic equation for arc elasticity, we subtract the term on the right and obtain Lyon and Simon's formula:

$$\text{adjusted} \quad e_p^1 = \frac{\dfrac{q_2^1 - q_1^1}{q_1^1} - \dfrac{\sum_{r=2}^{N} \left(\dfrac{q_2^r - q_1^r}{q_1^r} \right)}{N-1}}{\dfrac{P_2^1 - P_1^1}{P_1^1}}$$

A similar procedure can be followed for a multiplicative function:

$$q_t^r = a_{0t}^r \prod_{i=1}^{M} (X_{it}^r)^{a_{it}^r} (P_t^r)^{b_t^r}$$

The same basic assumptions hold for this model also, i.e.,

(1) $b_1^r = b_2^r$ for all r;

(2) $P_1^r = P_2^r$ for $r = 2, 3 \cdots N$; and

(3)
$$\frac{\Delta a_{0t}^1 \prod_{i=1}^{M} (X_{it}^1)^{a_{it}^1}(P_1^1)^{b_t^1}}{a_{01}^1 \prod_{i=1}^{M} (X_{i1}^1)^{a_{i1}^1}(P_1^1)^{b_1^1}} = \frac{\sum_{r=2}^{N} \dfrac{\Delta a_{0t}^r \prod_{i=1}^{M} (X_{it}^r)^{a_{it}^r}(P_t^r)^{b_t^r}}{a_{01}^r \prod_{i=1}^{M} (X_{i1}^r)^{a_{i1}^r}(P_1^r)^{b_1^r}}}{N-1}$$

where $1=$trial state and $r=$all others $(2 \cdots N)$.

Letting

$$a_{0t}^r \prod_{i=1}^{M} (X_{it}^r)^{a_{it}^r} = A_{0t}^r,$$

we can write unadjusted

$$e_p^1 = \frac{\dfrac{q_2^1 - q_1^1}{q_1^1}}{\dfrac{P_2^1 - P_1^1}{P_1^1}} = \frac{\dfrac{A_{02}^1(P_2^1)^{b_2^1} - A_{01}^1(P_1^1)^{b_1^1}}{A_{01}^1(P_1^1)^{b_1^1}}}{\dfrac{P_2^1 - P_1^1}{P_1^1}}$$
$$= \frac{\dfrac{A_{02}^1(P_2^1)^{b_2^1}}{A_{01}^1(P_1^1)^{b_1^1}} - 1}{\dfrac{P_2^1 - P_1^1}{P_1^1}}$$

The term $A_{02}^1(P_2^1)^{b_2^1} = q_2^1$ contains effects from changes in both own price and other variables which need to be separated. However, we can write

$$\frac{[A_{01}^1(P_2^1)^{b_2^1}][A_{02}^1(P_1^1)^{b_1^1}]}{A_{01}^1(P_1^1)^{b_1^1}} = A_{02}^1(P_2^1)^{b_2^1}$$

In this case, $A_{01}^1(P_2^1)^{b_2^1}$ shows the effect of a price change, holding other factors constant (which is the effect we want); and $A_{02}^1(P_1^1)^{b_2^1}$ indicates the effect of secular changes, holding own price constant. Substituting in the arc elasticity equation:

unadjusted

$$e_p^1 = \frac{\dfrac{\dfrac{[A_{01}^1(P_2^1)^{b_2^1}][A_{02}^1(P_1^1)^{b_1}]}{A_{01}^1(P_1^1)^{b_1^1}}}{A_{01}^1(P_1^1)^{b_1^1}} - }{\dfrac{P_2^1 - P_1^1}{P_1^1}}$$

Consider the numerator, which can be writte

$$\frac{[A_{01}^1(P_2^1)^{b_2^1}][A_{02}^1(P_1^1)^{b_1^1}]}{[A_{01}^1(P_1^1)^{b_1^1}][A_{01}^1(P_1^1)^{b_1^1}]} - 1$$

By assumptions (1), (2), and (3),

$$\frac{A_{02}^1(P_1^1)^{b_1^1}}{A_{01}^1(P_1^1)^{b_1^1}} = \frac{\sum_{r=2}^{N} \dfrac{q_2^r}{q_1^r}}{N-1}$$

Thus, if we divide the *first* term of th numerator by the mean ratio of q_2^r/q_1^r wher $r=2 \cdots N$, we are left with

$$\frac{A_{01}^1(P_2^1)^{b_2^1}}{A_{01}^1(P_1^1)^{b_1^1}} - 1$$

which shows the percentage change in quantit demanded resulting from a change in owr price, or

adjusted

$$e_p^1 = \frac{\dfrac{q_2^1/q_1^1}{\dfrac{\sum_{r=2}^{N} \dfrac{q_2^r}{q_1^r}}{N-1}} - 1}{\dfrac{P_2^1 - P_1^1}{P_1^1}}$$

When applied to Murphy's example,

adjusted $$e_p^1 = \frac{\dfrac{1.32/1}{1.10/1} - 1}{-.167} = -1.20$$

which with respect to the *arc* elasticity represents zero bias.

While division is the right procedure, the terms involved differ from those presented by Murphy. In addition to obtaining an incorrect answer, if we divide the two ratios suggested by Murphy we conceivably could obtain a positive

price elasticity even though the underlying demand function followed the usual downward sloping characteristic. For example, assume that secular changes in other regions (as well as in the base region) have resulted in less quantity being consumed in the second time period. On the other hand, assume that price in the trial region drops enough so that quantity demanded increases by more than enough to offset the secular decrease. Following Murphy's suggested procedure, a positive ratio would be divided by a negative ratio giving a negative number which in turn would be divided by the negative percentage change in price, a procedure that would give a positive price elasticity of demand.

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A Modified Adaptive Expectations Model*

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NERLOVE's reformation of Cagan's adaptive price expectations model has become a standard tool in the estimation of agricultural supply functions.[1] In this paper we propose a modified version of Nerlove's model which in addition to past prices takes into account observed deviations of yield from its normal value. We show that under certain assumptions our model has the desirable property of rationality as defined by Muth.

In the first section Muth's concept of rationality and the conditions under which Nerlove's adaptive expectations model is rational are briefly discussed. This is followed by a more general model of which both Nerlove's and this paper's models are special cases.

Adaptive Expectations and Rational Expectations

According to Muth [3], expectations are rational if they "... are essentially the same as the prediction of the relevant economic theory." Defined in this way, the form of the expectations model depends on the structure of the underlying economic model. Muth has shown that Nerlove's model,

$$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*)$$

where P_t^* and P_{t-1}^* are expected prices in period t and $t-1$, P_{t-1} is the actual price in period $t-1$, and β is the coefficient of expectations, is equivalent to the rational expectations model under certain conditions. Let us briefly examine these conditions. It is assumed that producers have to form expectations of prices for a commodity whose market is characterized by the following supply and demand equations:

$$Q_t^s = a + bP_t^* + U_t$$

$$Q_t^d = c + dP_t$$

where

- Q_t^s is the quantity supplied;
- Q_t^d is the quantity demanded;
- P_t^* is the market price expected to prevail during the period t;
- P_t is the market price in period t;
- U_t is a disturbance term which may represent variations due to weather or other factors influencing the supply.

If the average price expectation of producers is rational,

$$P_t^* = E(P_t).$$

It can be shown that adaptive expectations satisfy the above condition if the disturbance term U_t is a specific linear combination of independently distributed random variables ϵ_t with zero mean and common variance.[2]

$$U_t = \epsilon_t + \sum_{i=1}^{\infty} w\epsilon_{t-i}$$

$$E\epsilon_j = 0, \qquad E\epsilon_i\epsilon_j = \begin{cases} \sigma^2 & \text{if } i = j \\ 0 & \text{if } i \neq j \end{cases}$$

and

$$|w| < 1.$$

This condition is equivalent to assuming that the random shock, ϵ_t, has both a permanent and a transitory effect on U_t. A positive fraction, w, of ϵ_t permanently affects U_t, while the remainder, $1-w$, is transitory and thus has no effect on subsequent values of U. It can be shown that β, the coefficient of expectations, is given by

$$\beta = \frac{dw}{d-b}.$$

An alternative model in which adaptive expectations are rational is one in which the price consists of two components, again one of which may be considered permanent and the other transitory. This model may be expressed in the form:

$$P_t = \bar{P}_t + \eta_t$$

where $\bar{P}_t$ is the permanent component and η_t is the transitory component:

* I am grateful to referees of this Journal for their helpful comments.

[1] See Cagan [1] and Nerlove [4, 5].

[2] For a proof of this statement and a further discussion of rational expectations, see Muth [3] and Nerlove [6]. Their proof is equivalent to one we use here for the more general model.

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$$E\eta_i = 0 \quad \text{and} \quad E\eta_i\eta_j = \begin{cases} \sigma_\eta^2 & \text{if } i = j \\ 0 & \text{if } i \neq j \end{cases}$$

It is also assumed that

$$\bar{P}_t = \bar{P}_{t-1+\epsilon_t}$$

where ϵ_t is an independent random variable with mean zero and variance σ_ϵ^2. In this case the coefficient of expectation is a function of the relative variances of η and ϵ.[3]

A More General Model

In the models discussed by Muth [3] and Nerlove [5] the disturbance term is confined to the supply equation. This is not a necessary assumption, and a disturbance term can just as well be included in the demand equation. In fact, for the purpose of estimating the supply function, the inclusion of the disturbance term in the demand equation is more satisfactory. Otherwise, since U_t's are serially correlated, problems will arise in the estimation. Disturbance terms can, in fact, be included in both the supply and the demand function. Since the model of price expectation formation which we propose is a special case of this general model, the derivation of the latter is presented below.

Let us assume that both supply and demand functions contain a disturbance term:

$$Q_t^s = a + bP_t^* + U_t \tag{1}$$

$$Q_t^d = c + dP_t + V_t \tag{2}$$

If the variables are defined as deviations from their equilibrium values,[4] then

$$Q_t^s = bP_t^* + U_t$$

$$Q_t^d = dP_t + V_t.$$

From the market-clearing equation in each period we have

$$Q_t^d = Q_t^s. \tag{3}$$

It follows that

$$P_t = \frac{b}{d} P_t^* + \frac{1}{d}(U_t - V_t). \tag{4}$$

We assume that

$$U_t = \epsilon_t + w \sum_{i=1}^{\infty} \epsilon_{t-i} \tag{5}$$

and

$$V_t = \eta_t + x \sum_{i=1}^{\infty} \eta_{t-i} \tag{6}$$

where ϵ and η are independently distributed random variables with mean zero and variance σ_ϵ^2 and σ_η^2, respectively, and x and w are constants with absolute value less than one. Notice that if $x = w = 0$, i.e., if U_t and V_t are serially independent, there will be no tendency to change the expectation of the price. (This can easily be verified by examining equation (9)). Substituting for U_t and V_t, we get

$$P_t = \frac{b}{d} P_t^* + \frac{1}{d}\left(\epsilon_t - \eta_t + w \sum_{i=1}^{\infty} \epsilon_{t-i} - x \sum_{i=1}^{\infty} \eta_{t-i}\right). \tag{7}$$

For rational expectations,

$$E(P_t) = P_t^*. \tag{8}$$

Taking the expected value of (7) and using equation (8), we obtain

$$P_t^* = \frac{b}{d} P_t^* + \frac{1}{d}\left(w \sum_{i=1}^{\infty} \epsilon_{t-i} - x \sum_{i=1}^{\infty} \eta_{t-i}\right)$$

since $E\epsilon_t = E\eta_t = 0$.[5] Solving for P_t^* gives

$$P_t^* = \frac{1}{d-b}\left(w \sum_{i=1}^{\infty} \epsilon_{t-i} - x \sum_{i=1}^{\infty} \eta_{t-i}\right). \tag{9}$$

Substituting for P_t^* in (7), we get

$$\begin{aligned} P_t = {} & \frac{b}{d}\frac{1}{d-b}\left(w \sum_{i=1}^{\infty} \epsilon_{t-i} - x \sum_{i=1}^{\infty} \eta_{t-i}\right) \\ & + \frac{1}{d}\left(\epsilon_t - \eta_t + w \sum_{i=1}^{\infty} \epsilon_{t-1} - x \sum_{i=1}^{\infty} \eta_{t-i}\right). \end{aligned} \tag{10}$$

Therefore

$$\begin{aligned} P_t = {} & \frac{1}{d}(\epsilon_t - \eta_t) \\ & + \frac{1}{d-b}\left(w \sum_{i=1}^{\infty} \epsilon_{t-i} - x \sum_{i=1}^{\infty} \eta_{t-i}\right). \end{aligned} \tag{11}$$

Substituting equation (9) in equation (11), we have

[3] For a proof of this assertion, see Muth [2].

[4] The equilibrium values of P and Q may be obtained by setting $U_t = V_t = 0$, $P_t^* = P_t = \bar{P}$ and $Q_t^s = Q_t^d) = \bar{Q}_t$.

[5] The expected value of P_t is for given values of ϵ_{t-i} and η_{t-i}, $i = 1, 2 \cdots \infty$.

$$P_t = \frac{1}{d}(\epsilon_t - \eta_t) + P_t^*,$$

from which it follows that

$$(\epsilon_t - \eta_t) = d(P_t - P_t^*).$$

Therefore

$$(12) \quad (\epsilon_{t-i} - \eta_{t-i}) = d(P_{t-i} - P_{t-i}^*).$$

Lagging equation (9) by one period, it is clear that

$$(13) \quad P_{t-1}^* = P_t^* - \frac{1}{d-b}(w\epsilon_{t-1} - x\eta_{t-1}).$$

If $w=x$ or if either η_{t-1} or $\epsilon_{t-1}=0$, which implies that either the supply or the demand equation does not include a random disturbance, we can substitute equation (12) in equation (13) to get

$$P_{t-1}^* = P_t^* - \frac{dw}{d-b}(P_{t-1} - P_{t-1}^*).$$

Therefore

$$(14) \quad P_{t-1}^* = P_{t-1}^* = \frac{dw}{d-b}(P_{t-1} - P_{t-1}^*),$$

which is the adaptive expectations model with $\beta = dw/(d-b)$.

Equation (14) rather than equation (9) is generally used to represent the expectation of price, because ϵ_t and η_t are usually unobservable and cannot be directly substituted in equation (9). However, this need not always be the case. For instance, if the disturbance in the supply function is caused by weather we may have a direct observation of ϵ_t. It is reasonable to assume that farmers generally have some idea as to the state of harvest in any year, and it may be possible to incorporate this information about supply situations directly in the price expectation formulas rather than to rely solely on past prices. Furthermore, in some situations it may be possible to form a rational expectation of prices that is a function only of past prices. A model in which this may be the case is now examined.

A Special Case

It is assumed that the model is the same as the general model, except that the disturbance in the supply equation is given by

$$U_t = \epsilon_t.$$

$$E\epsilon_t = 0 \qquad E\epsilon_i\epsilon_j = \begin{cases} \sigma^2 & \text{if } i = j \\ 0 & \text{if } i \neq j \end{cases}$$

Here we are assuming that the U_t's are not serially correlated, a reasonable hypothesis if U_t is primarily due to variations in weather. Following exactly the same procedure as before, we get

$$(15) \quad \epsilon_{t-i} - \eta_{t-i} = d(P_{t-i}^* - P_{t-i}^*).$$

But since in this case $w=0$, equation (13) now becomes

$$(16) \quad P_{t-1}^* = P_t^* + \frac{x}{d-b}\eta_{t-1}.$$

Substituting for η_{t-1} in (16), we have

$$P_{t-1}^* = P_t^* - \frac{x}{d-b}d(P_{t-1} - P_{t-1}^*) + \frac{x}{d-b}\epsilon_{t-1}.$$

$$(17) \quad P_t^* - P_{t-1}^* = \frac{dx}{d-b}(P_{t-1} - P_{t-1}^*) - \frac{x}{d-b}\epsilon_{t-1}.$$

As we can see from equation (17), rational expectations in this model are a modified form of adaptive expectations.

The form of equation (17) is quite reasonable on intuitive grounds. One would expect farmer's reactions to price changes to depend on harvest conditions. If in the past they have observed a certain correlation between price and harvest conditions, they would try to discount that part of the price which they believe to be caused by an abnormality in supply. Since price changes can be due to disturbances in either supply or demand, the price expectation model has two parts, one to account for changes in the former and the other for adjusting to the latter.

For estimation purposes we must substitute for ϵ_{t-1} an observable variable. One which suggests itself most readily is the difference between the actual and the expected yield. Thus,

$$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*) + \delta(Y_{t-1} - Y_{t-1}),$$

where Y_{t-1} is the average per acre yield in period $t-1$ and Y_{t-1}^* is the expected yield which can be independently estimated from a time series of yields. The farmers would of course have some notion of normal yields. The model would be most appropriate in a relatively small geographical area in which we can rea-

sonably assume that the farmers are aware of the harvest conditions for the entire region. For larger markets various agricultural information services could replace the more intimate personal knowledge of the state of harvest.

Finally a word of warning about the use of the above price expectation model and, in general, other rational expectations models. First, empirically estimated supply functions often contain price ratios rather than absolute prices. It is argued that the underlying structure is similar to the general model presented earlier; it follows that the same price deflator is used in both the demand and supply equations. This may not be appropriate in some situations.

The second point concerns dynamic supply response and partial adjustment models.[6] The use of partial adjustment models in conjunction with rational expectations is not very satisfactory, the reason being that, when the demand is less than perfectly elastic, producers' supply response will affect prices. If their price expectations are to be rational, the producers must be aware of the distinction between short-run and long-run supply. If they expect a certain price in a given period, but cannot immediately adjust their supply to this equilibrium value, the actual price will be different from their expected price, which will no longer be rational. Thus the partial adjustment hypothesis is not consistent with the rational expectations hypothesis.

[6] For a discussion of partial adjustment models, see Nerlove [4, 5].

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Effects of Misspecifications of Log-Linear Functions When Sample Values are Zero or Negative*

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NONLINEAR FUNCTIONS of the form

$$(1) \qquad y = X_1^{\alpha_1} \cdots X_k^{\alpha_k} e^{\mu}$$

are commonly employed for empirical work in economics. The particular nonlinear functional form is popular principally because of its exhibited properties, which have convenient economic interpretations, and because of its successful application to various types of economic and physical data [1, 3, 5, 7]. Estimation of the parameters for (1) is typically based on a logarithmic transformation. That is, for a sample size n,

$$(2) \qquad \ln y_j = \alpha_1 \ln X_{1j} + , \cdots, + \alpha_k X_{kj} + \mu_j \qquad j = 1, 2, \cdots, n.$$

If the X_i, $i = 1, 2, \cdots, k$, are nonstochastic and of rank k, and if μ is distributed normally with zero mean and finite variance, σ^2, then the least squares estimators, $a_1, a_2, \cdots, a_k$, of the α_i, $i = 1, 2, \cdots, k$, in (2) are maximum likelihood and also best linear unbiased [4, pp. 164–180]. The logarithmic transformation therefore facilitates a convenient computational procedure which results in parameter estimates that have the usual desirable properties.[1]

A common problem in obtaining estimates of the α_i by utilizing the log-linear form occurs when there are zero or negative observations in the sample.[2] The logarithmic transformation for the nonpositive values that exist in the sample is not defined in the real space [8, pp. 48–52]. Hence, the maintained hypothesis is violated and the estimation procedure just described cannot be directly applied.

Three types of modifications or misspecifications of the sample data have been applied to permit estimation of the α_i from the related log-linear form [1, pp. 94–97 and 7, p. 572]. These are: (i) addition of a positive constant to all sample observations so that previously negative values become positive; (ii) replacement of negative or zero values within the sample by small positive constants; and (iii) exclusion of observations that include the nonpositive values from the remainder of the sample. Although these modifications are frequently applied in empirical work, their effects on the resulting parameter estimates are not generally known. For instance, Hu and Tseng [7] have only recently presented experimental results for the special problem of adding constants to positively valued independent variables in a log-linear model as a basis for providing some indication of the effect of such modifications on parameter estimates.

In this discussion we shall first give an analytical solution to the special problem of Hu and Tseng, i.e., the addition of constants to positively valued variables. The solution will then be used to suggest an alternative specification that is consistent with both observed zero or negative values for the X_i and the loglinear functional form. Moreover, for this alternative specification we demonstrate that it is possible to obtain parameter estimates that are consistent and asymptotically more efficient than those obtained by omitting negative-valued observations of the X_i and proceeding with the traditional approach.

Effects of Misspecifications when $X_{ij} > 0$

Consider the simplified version of equation (1):

$$(3) \qquad y = X_1^{\alpha_1} e^{\mu}.$$

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[1] Predicted values of y based on estimates from this particular function must be interpreted differently from those estimated in the usual linear case. The required differences in interpretation are indicated by Goldberger [3] and are derived from the discrepancy between the expected value of $\ln y$ and the natural log of the expected value of y. Additional results related to this question have recently been derived by Bradu and Mundlak [2].

[2] Negative or zero values for some of the observations in the sample may occur, for example, in data from controlled experiments for agricultural crops, in family budget studies in which zero expenditures are observed for various types of commodities, and in the differencing and indexing of prices that are sometimes employed in empirically oriented economic studies.

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Suppose that α_1 is to be estimated from a sample of size n. Assume a specification error of type (*i*) is introduced prior to the estimation of α_1 from the log-linear form of equation (3). In particular, assume a constant b is added to each value of X_{1j}, $j=1, 2, \cdots, n$. The misspecified equation is then

$$y_j = (X_{1j} + b)^{\alpha_1'} e^{\mu_j'} \tag{4}$$

where primes have been added to denote effects of the alteration in the value of variable $(X_{1j}+b)$ representing X_{1j}.

The least squares estimator of α_1', a_1', is given by

$$a_1' = \frac{\sum_{j=1}^{n} [1n(X_{1j} + b)][1ny_j]}{\sum_{j=1}^{n} [1n(X_{1j} + b)]^2}. \tag{5}$$

Upon substituting the "true" value for $1ny_j$, i.e., $1ny_j = \alpha_1 1nX_{1j} + \mu_j$, and employing an alternative expression for $1n(X_{1j}+b)$, i.e.,

$$1n(X_{1j} + b) = 1nX_{1j} + 1n\left(\frac{X_{1j} + b}{X_{1j}}\right),$$

the expected value of a_i can be shown to be

$$E(a_1') = \alpha_1 - \alpha_1 \tag{6}$$

$$\frac{\sum_{j=1}^{n} [1n(X_{1j} + b)]\left[1n\left(\frac{X_{1j} + b}{X_{1j}}\right)\right]}{\sum_{j=1}^{n} [1n(X_{1j} + b)]^2}.$$

Hence, unless $\alpha_1=0$ or $b=0$ in which case

$$1n\left(\frac{X_{1j} + b}{X_{1j}}\right) = 0,$$

a_1' is a biased estimator of α_1. It follows then that the magnitude of the bias is dependent upon the size of b and can easily be evaluated for specific X_{1j} and conditional values for α_1.

The second type of misspecification turns out to be a special case of the first. Effects of adding constants to selected X_{1j} in the sample can therefore be inferred from (6) by assuming that b is added to only a proper subset of the X_{1j}, say the first $p<n$ of the X_{1j}. It is clear from (6) that the resulting bias is smaller than for the specification of type (*i*).

The last type of misspecification—deleting those p observations that have been augmented by b—produces an unbiased estimator, if the omitted observations are regarded as outliers. However, discarding the information in the p excluded observations may lead to adverse effects on the variance of estimators so obtained. This consideration suggests a comparison of variances for the least squares estimators based on three types of misspecifications. By appropriate manipulation of $E[a_1' - E(a_1')]^2$ for each type of error in specification, the following expressions for sampling variances are derived:

$$\text{(i) Var } (a_1') = \frac{\sigma^2}{\sum_{j=1}^{n} [1n(X_{1j} + b)]^2}$$

$$\text{(ii) Var } (a_1') = \frac{\sigma^2}{\sum_{j=p+1}^{n} [1nX_{1j}]^2 + \sum_{j=1}^{p} [1n(X_{1j} + b)]^2} \tag{7}$$

$$\text{(iii) Var } (a_1') = \frac{\sigma^2}{\sum_{j=p+1}^{n} (1nX_{1j})^2}.$$

From (7) it follows that the variance of a_1', as calculated according to misspecification (iii), is always larger than that for misspecifications (i) or (ii). Hence, the choice among methods appears to depend upon a weighing of the bias against the improvement in efficiency, i.e., the mean square error.[3]

As would be expected, these conclusions are consistent with the results of the sampling experiments reported by Hu and Tseng [7]. However, contrary to the contention of these two authors, the method employed in deriving the results suggests that they have very little bearing on the situation in which some $X_{1j} \leq 0$. This inference follows from the observation that the "true" value for $y_j = \alpha_1 1nX_{1j} + \mu_j$ cannot be evaluated in real terms or, more generally, that the observations for which $X_{1j} \leq 0$ are not consistent with the maintained hypothesis. Hence, only type (iii) of the misspecifications, which in effect treats the nonpositive values of X_{1j} as outliers, is of consequence for the main problem being investigated. If useful conclusions are to be produced regarding the

[3] When these results are generalized to the case in which $1<k<n$, the conclusions remain unchanged. Furthermore, since the expression for the bias is known it is possible to derive a transformation of the data that yields unbiased estimators of the parameters $\alpha_1, \cdots, \alpha_k$.

comparative properties of parameters obtained from three types of misspecifications when $X_{ij} \leq 0$, a maintained hypothesis must be developed that is consistent with the observed data. We turn to this task next.

An Alternative Specification for $X_{1j} \leq 0$

The specification for $X_{1j} \leq 0$ is presented for the two-variable case in equation (8) which represents an alternative maintained hypothesis:

$$(8) \quad y_j = (X_{1j} + b_j)^{\delta_1} e^{\mu_j}; \quad j = 1, 2, \cdots, n,$$

where $b_j = b$, for $j = 1, 2, \cdots, p < n$ and $b_j = 0$ otherwise; $b_j + X_{ij} > 0$ for all j; and the assumed properties continue to hold for the error term e^{μ_j}. For this alternative maintained hypothesis, b can be treated as a parameter; the parameters can be estimated in the context of a logarithmic transformation; and the attributes of the functional form (1) continue to apply.

Least squares estimators of the parameters b and δ_1, denoted $\hat{b}$ and d_1, respectively, are obtained from the log-linear form of equation (8). To demonstrate this result, we first recognize that the restrictions on b_j imply that the n observations can be regarded as two separate samples satisfying the relations:

$$(9) \quad \begin{aligned} 1ny_j &= \delta_{11} 1n(X_{1j} + b) + \mu_j \\ & \qquad j = 1, 2, \cdots, p \quad \text{and} \\ 1ny_j &= \delta_{12} 1n X_{1j} + \mu_j \\ & \qquad i = p + 1, \cdots, n. \end{aligned}$$

The estimation problem is to find $\hat{b}$, d_{11}, and d_{12}, such that the sum of squares is minimized subject to the conditions that $\delta_{11} = \delta_{12}$ and $1n(X_{1j} + \hat{b}_j)$ is a real number for all j. Assuming that the latter constraint is implicitly satisfied,[4] the parameter estimators are obtained from the first order conditions for the Lagrangian:

$$(10) \quad \begin{aligned} L(\delta_{11}, \delta_{12}, b, \lambda) \\ &= \sum_{j=1}^{p} [1ny_j - \delta_{11} 1n(X_{1j} + b)]^2 \\ &\quad + \sum_{j=p+1}^{n} [1ny_j - \delta_{12} 1n X_{1j}]^2 \\ &\quad + 2\lambda(\delta_{11} - \delta_{12}). \end{aligned}$$

First order conditions $\partial L/\partial \delta_{11}$, $\partial L/\partial \delta_{12}$, and $\partial L/\partial \lambda$ are combined to give an expression for d_1:

$$(11) \quad d_1 = d_{12} = d_{11} = \frac{\sum_{j=1}^{p} 1ny_j 1n(X_{1j} + \hat{b}) + \sum_{j=p+1}^{n} 1ny_j 1n X_{1j}}{\sum_{j=1}^{p} [1n(X_{1j} + \hat{b})]^2 + \sum_{j=p+1}^{n} [1n X_{1j}]^2}.$$

The estimator in equation (11) indicates that once $\hat{b}$ is known d_1 can be derived by direct application of log-linear methods to the resulting sample data. The partial derivative of the Lagrangian with respect to b, together with equation (11), is used to solve for $\hat{b}$. That is, $\hat{b}$ is obtained from

$$(12) \quad \sum_{j=1}^{p} \frac{1}{X_{1j} + \hat{b}} [1ny_j - d_1 1n(X_{1j} + \hat{b})] = 0.$$

Solution of equation (12) for $\hat{b}$ turns out to be rather complex; hence, we consider the simplified problem $X_{1j} \leq 0$, $j = 1, 2, \cdots, p$, all of the same value, before attempting a more general solution for $\hat{b}$.[5] For $X_{1j} + \hat{b}$, $j = 1, 2, \cdots, p$ a constant the term $1/(X_{1j} + \hat{b})$ can be eliminated from (12) by division. Thus, on substituting for d_1 from (11), obtaining a common denominator, and taking the sum over p, it follows from (12) that $1n(X_{1j} + \hat{b})$, $j = 1, 2, \cdots, p$, is

$$(13) \quad 1n(X_{1j} + \hat{b}) = \frac{\sum_{j=p+1}^{n} [1n X_{1j}]^2}{\sum_{j=p+1}^{n} 1ny_j 1n X_{1j}} \cdot \frac{\sum_{j=1}^{p} 1ny_j}{p};$$

that is, $1n(X_{1j} + \hat{b})$ is the inverse of the regression coefficient obtained from the data for which $X_{1j} > 0$ multiplied by the mean of the $1ny_j$ corresponding to the $X_1 \leq 0$. Hence, for this simplified case, $\hat{b}$ puts the mean of the logged values for y_j, $j = 1, 2, \cdots, p$ on the regression surface as calculated from the $p+1, \cdots, n$ observations satisfying the maintained hypothesis for (3).

[4] The parameter b turns out to take on a value which places the $1ny_j$, $j = 1, 2, \cdots, p$ near the regression line calculated from the data for which $X_{1j} > 0$. An exception may occur when there is wide dispersion in the $X_{1j} \leq 0$. However, for analytical convenience, the assumption that $1n(X_{1j} + \hat{b}_i)$ is real number for all j will be maintained.

[5] This situation is not as special as it at first may appear. For example, it would be applicable in budget studies in which zero expenditures are reported and in response function estimates for agricultural crops that are based on experimental data containing zero control levels for some or all factors.

The generalization to $X_{1j} \leq 0$ (not all of the same value) requires two approximations if the nonlineality implicit in expression (12) is to be avoided. In particular, for sufficiency small variation in the X_{1j}, $j=1, 2, \cdots, p$, $X_{1j}+b$ in (12) can be regarded as a constant.[6] In addition, from a Taylors Series Expansion of $1n(X_{1j}+b)-1n(X_{1j}-\hat{b})$ about 1 it can be shown that deviations from $1n(X_{1j}-\hat{b})$ are approximated by $X_{1j}-\overline{X}_1$.[7] If we denote $X_{1j}-\overline{X}$ as ξ_j and substitute these approximations into (12), the resulting estimator of b, $\hat{b}$ is given by $\overline{X}_1$ and the numerical value for the antilog of

$$1n\overline{(X_{1j}+b)} = \frac{\dfrac{p\sigma_\xi^2 + \sum_{j=p+1}^{n} [1nX_{1j}]^2}{\sum_{j=1}^{p} 1ny_j\xi_j + \sum_{j=p+1}^{n} 1ny_j 1nX_{1j}}\sum_{j=1}^{p} 1ny_j}{p}. \tag{14}$$

As indicated above, the approximation is good only when X_{1j}, $j=1, 2, \cdots, p$ are in close proximity. In the event that these conditions are not met, the estimator of b can be improved by iterating the computation of $1n\overline{(X_{1j}+\hat{b})}$ in equation (14).

Since d_1 and b, aside from the problems of approximation mentioned above, are also maximum likelihood estimators, it follows that they are asymptomatically unbiased and efficient.[8] The asymptotic expression for the variance of d_1 is easily derived from (11) and is identical with (ii) in (7).[9] Thus, conclusions similar to those obtained earlier apply. The asymptotic variance of d_1 is clearly smaller than that for a_1' in the situation in which the p sample values corresponding to $X_{1j} \leq 0$ are excluded. Hence, if d_1 and a_1' are similar, the procedure just derived appears to be the better of the two alternatives.

Extension of these results to the situation in which $k>1$ presents further nonlinearity problems. However, under the approximating assumptions employed thus far, the computational task remains manageable. To illustrate, consider the case in which ith X_{ij} has $j=1, 2, \cdots, p$ identical nonpositive values. Let X denote the matrix of n observations on the k independent variables. For purposes of convenience, X is written as

$$X = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix},$$

where X_1 contains the first p of the observations and X_2 contains observations $p+1, \cdots, n$. The vector of observations on the dependent variable $y=(y_1, y_2)'$ is similarly partitioned. With $\delta=(\delta_1, \delta_2)'$ defined as the $2k$ vector of parameters and μ as the error vector, the model to be estimated can be written $y=X\delta+\mu$.

Proceeding as in the two-variable problem, we set up the Lagrangian for the partitioned sample data:

$$L(\delta_1, \delta_2, \lambda, b) = (y - X\delta)'(y - X\delta) - 2\lambda'(\delta_1 - \delta_2). \tag{15}$$

First order conditions for maximizing the Lagrangian can be combined to demonstrate that the least squares estimator of δ_1 and δ_2 is $d_1=d_2=(X_1'X_1+X_2'X_2)^{-1}(X_1'y_1+X_2'y_2)$. The partial derivative with respect to λ is given by

$$1(y_1 - X_1d_1) = 1(\hat{u}_1) = 0 \tag{16}$$

where 1 is the sum vector and $\hat{u}_1$ denotes the vector of least squares residuals. Substitution for d_1 produces an expression that is a polynomial in $\hat{b}$.[10] However, the form of equation (16) suggests an easy computational procedure for approximating $1n(X_{ij}+\hat{b})$: Simply substitute the estimator of δ_2 from the part of the

[6] This approximation is required to avoid severe difficulties with nonlinearities. In the event that the dispersion among the X_{1j}, $j=1, 2, \cdots, p$ is large enough that the approximation is not appropriate the problem can be handled by partitioning the $X_{1j} \leq 0$ into two groups and estimating a constant for each.

[7] $$1n(X_{1j}+b) \approx \frac{X_{1j}+b-1}{1} = (X_{1j}-\overline{X}_1)+(\overline{X}_1+b-1)$$

and

$$1n\overline{(X_{1j}+b)} \approx \frac{1}{p} \sum (X_{1j} - \overline{X}_1)+(\overline{X}_1+b-1).$$

Therefore $1n(X_{1j}+b)-1n(X_{1j}+b) \approx X_{1j}-X_1$.

[8] For a derivation of the maximum likelihood estimation results see Goldberger [4, pp. 207–212].

[9] Since b is consistently estimated by (13) or (14), it follows by using Slutsky's theorem regarding asymptotic expectations of products of random variables [4, p. 270] that the variance can be directly derived from (11).

[10] The exact expression for is given b$\hat{b}$y $1(y_1-[I-X_1(X_2'X_2)^{-1}X_1'] [X_1'\delta_2+X_1'(X_2'X_2)^{-1}X_1'y_1]$, where δ_2 is the least squares estimate of δ_2 from X_2. Since the ith column of X_1 contains the constant value $\ln(X_{ij}+\hat{b})$, the expression is polynomial in $\ln(X_{ij}+\hat{b})$.

data contained in y_2 and X_2, $\underline{d}_2$ into equation (16). Denoting the elements of $\underline{d}_2$ as $\underline{d}_{21}$, $\underline{d}_{22}$, $\cdots$, $\underline{d}_{2k}$ and the means of the columns of X_2 as $\overline{1nX}_{21}$, $\overline{1nX}_{22}$, $\cdots$, $1n(X_i+\hat{b})$, $\cdots$, $\overline{1nX}_{2k}$, the approximate value of $1n(X_i+\hat{b})$ from (16) and $\underline{d}_2$ is

$$\begin{aligned}1n(X_i + \hat{b}) = \underline{d}_{2i}^{-1}[\overline{1ny} - (&\underline{d}_{21}\overline{1nX}_{21} \\ &+ \cdots + \underline{d}_{2i-1}\overline{1nX}_{2i} \\ &+ \underline{d}_{2i+1}\overline{1nX}_{2i+1} \\ &+ \cdots + \underline{d}_{2k}\overline{1nX}_{2k})].\end{aligned} \tag{17}$$

On substituting the approximated value for $1n(X_i+\hat{b})$ into the sample data, estimating the parameters from the full-data set, and then repeating the above procedure (i.e., iterating until a satisfactory indication of convergence has been achieved), the least squares estimator for $1n(X_i+\hat{b})$ can be obtained. Hence, although direct solution for the parameter indicating the distance by which the $X_{ij}\leq 0$ are to be moved into the positive orthant presents some computational problems, the numerical procedure for approximating it is quite straightforward. Furthermore, apart from the possibility of multiple stationary values for (15) in $1n(X_1+\hat{b})$, the similarity of (17) to (13) suggests that the approximating procedure should give a satisfactory value for $1n(X_i+\hat{b})$ in a relatively small number of iterations.

Conclusions

The applicability of a multiplicative functional form and the related log-linear estimation procedure is admittedly a precarious approach when sample data include negative or zero values in some of the observations on the independent variables. The hazards result largely from the inconsistency of the observed sample information with a maintained hypothesis of the type mentioned in connection with equation (1). In this paper we have indicated the limitations associated with the traditional log-linear functional form and have provided an alternative log-linear form within the context of which negative values for the X_{ij} can be treated. Although the alternative log-linear form provides estimates that are only asymptotically unbiased and efficient, the nature of the expressions for b would indicate that improvements in efficiency occur for relatively small sample sizes and relatively small proportions of the $X_{ij}\leq 0$.

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A Model for Agricultural Policy: An Addendum

Micha Gisser

In two previous articles I have developed a model of the farm labor market [1, 2]. One of the basic assumptions underlying this model was that capital is exogenous to the farm labor market. Geometrically this assumption boils down to a vertical supply curve whose shift, right or left, is determined by economic forces outside the farm sector. This model will be known here as Model A. Utilizing some accepted econometric estimates, I obtained estimates for parameters appearing in the two reduced equations for farm labor.

In this addendum I replace the assumption of a vertical supply curve by a different assumption according to which the farm sector is confronted with a horizontal supply curve of capital. In other words, the farm sector has no influence over the cost of capital which is the exogenous variable. This model will be known as Model B. My main purpose is to compare the empirical estimates obtained by using the two different models. In addition to comparison per se, Model B yields a by-product: It enables us to examine the effects of a change in the price of capital on returns to farm labor and farm employment.

The Two Models

A by-product of this paper is an improved notation over that employed in the prior papers. The earlier notation could confuse an unwary reader. Equation (5) in [1] is called the "demand for labor," which is not a very apt definition of marginal physical product. The symbols a_2 and a_3 have one meaning in equations (1) and (3) and another meaning in equation (8) [1, p. 809]. This could have been avoided by writing equation (1) as $W_d^* = v_1 + v_2 L + v_3 C$ and then, after equation (8) was derived, let

$$v_1 = \left[1 + a_2 - \frac{H}{\eta} + \left(1 + \frac{1}{\eta}\right)K\right],$$

$$v_2 = \left[a_2\left(1 + \frac{1}{\eta}\right) + \frac{1}{\eta}\right]$$

and

$$v_3 = \left[a_3\left(1 + \frac{1}{\eta}\right)\right].$$

In order to avoid this confusion, instead of starting with a demand and supply of farm labor, I start now with the final output sector and derive from it the demand for farm labor.

As in my earlier articles, to keep the presentation in manageable proportions all variables are expressed in logarithms. The final output sector can be described as follows:

(1) Production function:

$$Q = K + (1 + a_2)L + a_3 C$$

(2) Marginal physical product of labor:

$$W_d = K + (1 + a_2) + a_2 L + a_3 C$$

(3) Marginal physical product of capital:

$$I_d = K + a_3 + (1 + a_2)L + (a_3 - 1)C$$

(4) Value marginal product of labor:

$$W_d^* = W_d + P$$

(5) Value marginal product of capital:

$$I_d^* = I_d + P$$

(6) Demand for final output:

$$P = \frac{1}{\eta}Q - \frac{H}{\eta}$$

where Q, K, L, C, W_d, I_d, W_d^*, I_d^*, P, η, and H stand for agricultural output, the shift in the production function, labor, capital, marginal physical product of labor, marginal physical product of capital, the value of marginal physical product of labor, the value of marginal physical product of capital, price of final output, price elasticity of final output, and the horizontal shift in the demand for output, respectively. By substituting the right side of (2) for W_d in (4), the right side of (1) for Q in (6), and the right side of (6) for P in (4), we obtain the (adjusted) demand function for labor:

$$W_d^* = 1 + a_2 + \left[a_2\left(1 + \frac{1}{\eta}\right) + \frac{1}{\eta}\right]L + a_3\left(1 + \frac{1}{\eta}\right)C - \frac{H}{\eta} \qquad (7)$$

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$$+\left(1+\frac{1}{\eta}\right)K.$$

The supply function of labor is

$$W_s^* = -b_2b_1 + b_2L \tag{8}$$

where b_1 reflects the horizontal shift in the supply of labor. Note that (unlike in the earlier articles) the wage rate is denoted by W_s^* rather than W_s, because the supply price is set equal to VMP, not to marginal physical product.

A procedure similar to the one used to obtain relation (7) yields the adjusted demand function for capital:

$$\begin{aligned} I_d^* = a_3 &+ \left[a_2\left(1+\frac{1}{\eta}\right)+\left(1+\frac{1}{\eta}\right)\right]L \\ &+ \left[a_3\left(1+\frac{1}{\eta}\right)-1\right]C - \frac{H}{\eta} \\ &+ \left(1+\frac{1}{\eta}\right)\cdot K. \end{aligned} \tag{9}$$

Notice that a supply function of capital is not introduced because of the assumption that the price of capital is an exogenous variable. Formally this can be written as I_s = constant, and in equilibrium $I_s = I_d^* = I^*$.

Model A

Reducing equations (7) and (8) yields the two reduced forms of Model A:

$$\begin{aligned} W^* = \alpha &- \frac{b_2}{D\eta}H + \frac{b_2\left(1+\frac{1}{\eta}\right)}{D}K \\ &+ \frac{a_3\left(1+\frac{1}{\eta}\right)b_2}{D}C \\ &+ \frac{\left[a_2\left(1+\frac{1}{\eta}\right)+\frac{1}{\eta}\right]b_2}{D}b_1 \end{aligned} \tag{10}$$

$$\begin{aligned} L = \beta &- \frac{1}{D\cdot\eta}H + \frac{\left(1+\frac{1}{\eta}\right)}{D}K \\ &+ \frac{a_3\left(1+\frac{1}{\eta}\right)}{D}C + \frac{b_2}{D}b_1 \end{aligned} \tag{11}$$

where α and β are constants and

$$D = b_2 - \left[a_2\left(1+\frac{1}{\eta}\right)+\frac{1}{\eta}\right].$$

Model B

Equations (7), (8), and (9) can be written, using matrix notations, as follows:

$$\begin{bmatrix} -1 & \left[a_2\left(1+\frac{1}{\eta}\right)+\frac{1}{\eta}\right] & a_3\left(1+\frac{1}{\eta}\right) \\ -1 & b_2 & 0 \\ 0 & \left[a_2\left(1+\frac{1}{\eta}\right)+\left(1+\frac{1}{\eta}\right)\right] & \left[a_3\left(1+\frac{1}{\eta}\right)-1\right] \end{bmatrix} \begin{bmatrix} W^* \\ L \\ C \end{bmatrix} = \begin{bmatrix} \frac{1}{\eta}H - \left(1+\frac{1}{\eta}\right)K - (1+a_2 \\ b_2b_1 \\ I^* + \frac{1}{\eta}H - \left(1+\frac{1}{\eta}\right)K - a \end{bmatrix} \tag{12}$$

Reducing equation (12) yields the followin three reduced forms:

$$\begin{aligned} W^* = \gamma &- \frac{b_2}{\Delta\eta}H + \frac{\left(1+\frac{1}{\eta}\right)b_2}{\Delta}K \\ &- \frac{a_3\left(1+\frac{1}{\eta}\right)b_2}{\Delta}I^* \end{aligned} \tag{13}$$

$$+\frac{\left[\left(1+\frac{1}{\eta}\right)(a_2+a_3)+\frac{1}{\eta}\right]b_2}{\Delta}b_1$$

$$L=\kappa-\frac{1}{\Delta\eta}H+\frac{1+\dfrac{1}{\eta}}{\Delta}K$$

$$-\frac{a_3\left(1+\dfrac{1}{\eta}\right)}{\Delta}I^* \tag{14}$$

$$+\frac{\left[1-a_3\left(1+\dfrac{1}{\eta}\right)\right]b_2}{\Delta}b_1$$

$$C=\lambda-\frac{1+b_2}{\Delta\eta}H$$

$$+\frac{(1+b_2)\left(1+\dfrac{1}{\eta}\right)}{\Delta}K$$

$$+\frac{\left[a_2\left(1+\dfrac{1}{\eta}\right)+\dfrac{1}{\eta}-b_2\right]}{\Delta}I^* \tag{15}$$

$$+\frac{\left(1+\dfrac{1}{\eta}\right)(1+a_2)b_2}{\Delta}b_1$$

vhere Δ is the determinant of the matrix which s premultiplied by the vector (W^*LC) in the et (12), and γ, κ and λ are constants.

Comparison of Empirical Estimates: Model A versus Model B

The econometric estimates of the parameters .ppearing in both models are summarized in 'able 1.

[able 1. Econometric estimates of parameters

Parameter	Symbol	Value
rice elasticity of demand for output	η	−0.25, −0.50
oefficient of labor in the production function	$1+a_2$	0.50
oefficient of capital in the production function	a_3	0.30
eciprocal of supply elasticity of labor	b_2	0.30, 1.00

'he comparison of parameter values is carried ut in Table 2.

The coefficients of H, K, and b_1 for reduced equations of wages and labor, have the same sign in Model A and Model B. This is expected since Model B is a generalization of Model A. The coefficient of I^*, the price of capital in Model B, has the opposite sign of the coefficient of C, capital in Model A. This is hardly suprising for a model employing the price of capital versus a model employing the quantity of capital. Thus, the qualitative results reported in [2] do not change under Model B.

In this paper, as in the earlier articles, capital does not include land. The estimates of capital coefficients are based on studies by Griliches [4] and myself [3]. The estimate of a_3 is intended to provide an order of magnitude rather than a precise statistical measurement. The attention of the reader is called to the fact that in an earlier paper [1, p. 812] farm property, including land, was used in estimating the capital growth rate. This was dictated by data limitation.

The coefficients of b_1, the shift in supply of farm labor, are almost identical for wages and labor in the two models. Hence, the results reported in [1] remain unchanged under Model B.

Finally, if we select the version $b_2=0.30$, $\eta=-0.25$ under Model B, a subsidy on capital leading to a 10 percent reduction in the cost of capital to farmers will result in 0.7 percent reduction in farm wages, 2.3 percent reduction in farm employment, and 7.1 percent increase in the use of farm capital.

To illustrate that Model B is in effect a generalization of Model A, note that if we are *given* a 7.1 percent increase in the use of farm capital, then we are back in Model A. Using Table 2 for Model A, $b_2=0.30$ and $\eta=-0.25$, we find a corresponding percentage change of -0.7 percent in wages and -2.3 percent in farm employment, which checks with the changes presented for Model B.

For the same version under Model B, a 10 percent rightward shift in the demand for farm output will result in 3 percent increase in farm wages, 10.1 percent increase in farm labor use, and 13.1 percent increase in capital.

Under Model A, the corresponding condition would be to combine a 10 percent rightward shift in the demand for farm output with 13.1 percent increase in capital. The results are:

(a) Percentage change in farm wages

$$0.43\times 10\text{ percent}-0.10\times 13.1\text{ percent}$$
$$=3.0\text{ percent}$$

Table 2. Values of coefficients of reduced forms appearing in Model A and Model B

Value of b_2	Endogenous variable	Model	Coefficients of: H A shift in the demand for farm output	K A shift in the production function	Capital: C Farm capital	Capital: r^* Price of farm capital	b_1 A shift in the supply of farm labor
					$\eta=-0.25$		
0.30	W	A	0.43	−0.32	−0.10		−0.27
	W	B	0.30	−0.23		0.07	−0.26
	L	A	1.43	−1.07	−0.32		0.11
	L	B	1.01	−0.76		0.23	0.14
	C	B	1.31	−0.98		−0.71	−0.11
1.00	W	A	1.14	−0.86	−0.26		−0.71
	W	B	0.76	−0.57		0.17	−0.64
	L	A	1.14	−0.86	−0.26		0.29
	L	B	0.76	−0.57		0.17	0.36
	C	B	1.51	−1.13		−0.66	−0.28
					$\eta=-0.50$		
0.30	W	A	0.33	−0.17	−0.05		−0.25
	W	B	0.27	−0.14		0.04	−0.25
	L	A	1.11	−0.56	−0.17		0.17
	L	B	0.91	−0.46		0.14	0.18
	C	B	1.19	−0.59		−0.82	−0.07
1.00	W	A	0.80	−0.40	−0.12		−0.60
	W	B	0.64	−0.32		0.10	−0.58
	L	A	0.80	−0.40	−0.12		0.40
	L	B	0.65	−0.32		0.10	0.42
	C	B	1.29	−0.65		−0.81	−0.16

(b) Percentage change in farm labor

$$1.43 \times 10 \text{ percent} - 0.32 \times 13.1 \text{ percent} = 10.1 \text{ percent}$$

Again, these results check with changes presented for Model B.

In summary, the conclusion that *qualitative results do not change under Model B* might miss the point that the *quantitative results should be identical for corresponding conditions*. As illustrated above, obtaining corresponding conditions involves changing capital under Model A to adjust to a change in capital indicated by Model B.

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Returns to Human and Research Capital in the Non-South Agricultural Sector of the United States, 1949–1964*

GIDEON FISHELSON

ALTHOUGH FARM FAMILIES constitute a small fraction of all United States families, they account for much of the observed poverty [14]. Farm income is the sum of the returns to physical capital (land, buildings, machinery), to physical family labor, and to human capital. Hence, one of the reasons for the relatively high percentage of farm families in the low income group might be their small stock of human capital. The research reported here attempts to answer the question whether more public investment in human capital employed in agriculture would be profitable. The answer is reached through the estimation of the rate of return to human capital in the agricultural sector.

To make the study manageable, investment in human capital was restricted to public expenditure on (1) formal education (schooling) of farm operators and (2) nonformal education (extension and vocational education). Highly important by-products of the estimation procedure are the estimates of the returns to other inputs employed, especially public investment in research.

The Model, Variables, and Results

The marginal product of human capital was calculated through the estimation of a farm production function. The function estimated was an exponential one. The unit of observation was the "average" farm in each state in the years 1949, 1954, 1959, and 1964. Together with the conventional inputs (land, labor, machinery, fertilizers, and cash expenditures), three intangible capital inputs were included: (1) the per operator stock of human capital produced by schooling, (2) the per farm stock of human capital produced through extension and vocational training, and (3) the per farm stock of research capital.

The operational definitions of the stocks of human and research capital differ in three ways from their definitions in other studies that investigate the returns to these stocks in the agricultural sector:

(1) Total current public expenditure per pupil in rural areas during the operator's school years was used as a proxy variable for human capital produced by schooling. The use of this operational definition as a proxy variable for human capital assigns different stocks of human capital to operators who completed the same number of years of school at different periods or in different states, even if the number of days of attendance was the same—implying that a year of schooling is not a homogeneous unit of measurement.[1]

(2) The distributed lag function employed for transferring investments in research to research capital utilized in production was based on the rate of adoption of an agricultural innovation—hybrid corn in the corn belt states [5]. (Compare with [1, 6, 15].)

(3) The geographical borders for the relevant investments in research capital were expanded from a state to a production region [6, 15].

The common characteristic of the three stocks is that they were measured by their cost of production. Yet, by employing total per operator public expenditure on schooling as a proxy of the stock of human capital produced by schooling, two components of the cost of production were omitted. The first is income foregone; the second, private expenditure incurred during schooling. In the case of up to eight years of schooling, however, it is proposed that income foregone be disregarded [13], while private direct expenditure incurred for schooling at the elementary and secondary levels is shown to be small relative to public expenditure [8]. Human capital produced by extension and vocational education was approximated by the expenditures on those activities per farm, lagging them by the sequence 0, .3, .5, and .2 for the years t, $t-1$, $t-2$, and $t-3$, respectively.[2]

* This research note is based on a section of my Ph.D. thesis [2]. I am indebted to Dr. L. Ihnen for his close guidance while I was working on my thesis and to the anonymous reviewers whose comments guided me in revising a previous draft of this paper.

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[1] Griliches [6] assumed constant quality of a year of schooling over states and over time and slightly different qualities for different years of schooling. An assumption of overall homogeneity (over states, time, and years of schooling) was implicitly made when the number of years of school completed was used as the schooling input in [3, 9, 10, 15].

[2] The adult vocational agricultural education variable

Research capital per farm was defined as total public expenditure on research in the production region within which the farm is located divided by the number of farms in the corresponding state, lagging it by the sequence 0, .003, .004, .010, .021, .043, .083, .139, .189, .190, .144, .087, .045, .022, .010, .006, and .004 for the years t to $t-16$ respectively.[3]

Several attempts to estimate the production function for the whole United States yielded questionable results. These unsatisfactory results may be due to the difficulty of measuring human capital in the South.[4] The results of estimating the production function for the non-southern states resulted in positive but insignificant coefficients of the three stock variables and a nonsignificant increase in the coefficient of determination (R^2) when tested against an estimate not including those variables. The presence of insignificant coefficients accompanied by high simple correlations among the explanatory variables suggested the possibility of multicolinearity (the correlation between human capital produced by schooling and cash expenditures per farm (.88) was close to the regression multiple correlation coefficient (.98)). Thus, it was decided to utilize prior information when analyzing the production function. This information—the equality of the share of the variable inputs (cash expenditures and machinery cost) to their elasticity of production—was imposed on the estimated relations. Although the significance of the human capital coefficients have been improved (the t values became 1.82 and 1.84 for schooling and for extension and vocational education, respectively), research stayed insignificant (t is 1.13). The inclusion of time dummy variables, while hardly affecting the coefficients and significance of the material inputs, lowered by more than 50 percent the coefficients of the three additional variables, causing them to become en tirely insignificant ($t<1.0$). The apparen reason for these changes is the high positive cor relations between time and each of those vari ables. The time effect between 1949 and 196 is found to be significant (the 1964 coefficient i .042 with a t value of 2.3) even at the presenc of the human and research capital variables implying that productivity not accounted fo by formal and informal education and researcl increased at that period by 11 percent ($10^{.042}$).

The VMP's of the material inputs are of ver reasonable magnitudes (land, .13 dollars pe dollar per year; labor, 11.4 dollars per day; an fertilizers, 614.0 dollars per ton of weighte plant nutrients). The VMP's of the human an research capital variables, although insignifi cant, are high (schooling, .25 dollars per dollar o stock per year; extension and vocational educa tion, 6.0 dollars per dollar of utilized capita stock; research, 12.6 dollars per dollar of uti lized capital stock). The estimated correspond ing internal rates of return to the investment are: to schooling, 9.6 percent when assumin that the returns occur between the ages 25 t 65 and 25 percent if between the ages 15 to 65 to extension and vocational education, 19 percent, and if adjusting as Griliches [6], 2 percent; to research, 39 percent, and if adjustin as Griliches [6], 11 percent.

A comparison of these estimates of th internal rates of return to schooling with thos reported by Hansen [8] and Hanoch [7] indi cates that their estimates for the range of 0–4 t 12 years of schooling were close to the margina rates estimated in this study. The rate reporte by Hansen is 13.6 percent; by Hanoch, 33. and 18.0 percent for northern Whites and non Whites, respectively. The return to researc (unadjusted) is also very close to those esti mated by Griliches [5] for hybrid corn; b Schultz [13] for the whole United States agri culture; and by Mansfield [11] for various in dustries. With regard to extension service there is no other study to refer to. However given the relatively high rate of return to forma schooling, the estimated very high rates of re turn to specific education are not entirely un expected.

Conclusions and Reservations

The methodological and empirical advantag of the employment of a production functio model for measurements of returns to thes investments stems from its direct bridging be

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was disregarded in [6] and [15]. In [9] and [16], both extension and vocational education are disregarded. In [6] and [15], extension and research are summed into a single input. The same procedure was followed in [1].

[3] Data on private expenditure on agricultural research by state or region were not available.

[4] In this study the following states were regarded as the South: Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, and Louisiana. The major cause of this difficulty is the inequality between the racial composition of the school age population some forty years ago (the average age of farm operators in the South ranged between 45 and 55) and the racial composition of the current population of farm operators.

tween the investment and the functions it is expected to perform. Yet the high positive correlations among the inputs (inclusive of the nonmaterial ones) cast doubts on the estimated contribution of a single input. This point is well picked out in this study; e.g., the very high rates of return to extension and vocational education are derived from regression coefficients that are not significant. Hence, a less aggregate analysis (down to individual farm operators) seems to be more appropriate when the aim is the estimation of returns to human capital. Another direction of improvement to be considered regards the simultaneous determination of the quantity of inputs used in production, thus requiring a simultaneous equation analysis (e.g., Mundlak [12]).

The construction of the research capital variable to be employed in the regression analysis as well as the accounting for private research and extension activities are other objectives to be aimed at in forthcoming studies of this type.

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EIDTOR'S NOTE: This section of the *American Journal of Agricultural Economics* may include comments on the replies to previous articles and other literature in agricultural economics, suggestions for improving the effectiveness of the AAEA, discussions of changes in emphasis needed within the profession, and contributions on other topics of interest and importance to agricultural economists. Manuscripts submitted for this section should be prepared in accordance with the guide appearing on the inside of the back cover of this issue and should not exceed 1,000 words.

Communications

"MODERNIZATION EFFECT" UPON EXPORTS OF AGRICULTURAL PRODUCE: SOUTH KOREA: COMMENT

Professor Cho [2] asserts that supply conditions rather than demand deficiency explains much better the post-1945 export lag of agricultural products from less developed countries. This comment accepts this general proposition but takes issue with the example and analysis he used to prove it. In brief, Professor Cho argues that during the Japanese colonial period the Korean land tenure system channeled a large share of the exported rice through landlord hands. Small family farms had little or no rice surplus after paying rent and their marginal propensity to consume rice was high. The postwar land reform redistributed income more equally so that rural rice consumption rose. Cho concludes that this modernization effect influenced supply sufficiently to cause rice exports to disappear.

I seriously doubt that the income redistribution effect of this land reform was strong enough in the early postwar period to cause rural rice consumption to rise. After stating why I believe this to be so, I shall submit an alternative explanation to account for the rice export decline.

Although rents were reduced by governmental decree on October 5, 1945, a maximum rent in money or in kind was limited to one-third of the crop, and all landlords were ordered to file written leases in local land offices, "the rent-reduction ordinance was widely violated, and the requirement about written leases was completely ignored" [4, p. 7]. Landlords continued to receive various special gifts and payments from tenants who preferred not to complain about such practices because of their fear of eviction or retaliation [4, p. 7]. Late in October 1945 roughly 600,000 acres of former Japanese-owned land were brought under the management of the American-created New Korea Company; this land was mapped but not sold to tenants because Korean political leaders could not agree on a plan for distributing privately owned land. In March 1948 the military governor, Major General W. F. Dean, authorized the sale of Japanese land, and the New Korea Company was abolished and replaced by the National Land Administration Agency which sold 700,000 farm plots within several months. A new legislature elected in the same year responded to this action and passed a land reform bill early in 1949. President Syngman Rhee announced the law would be effective on July 1, 1950, but the outbreak of war delayed its implementation until the mid-1950's.

The sudden Japanese departure and collapse of trade and marketing caused severe consumer goods shortages and a near breakdown in trade between towns and countryside, so that the terms of trade turned severely against the peasant and continued in this fashion through the Korean War and into the late 1950's. Cho admits that cities had great difficulty in obtaining rice from villages in South Korea in 1946 [2, p. 95], but he attributes this to the fact that "a relatively high price inelasticity of demand for food has made the income redistribution consequent upon modernization a very forceful factor in determining the export pattern of South Korea" [2, p. 95]. As mentioned above, it is very questionable that an income redistribution effect operated strongly in the 1945–49 period because of the conciliatory manner in which land reform was carried out.

In addition to marketing problems and consumer goods shortages, the south no longer imported millet and sorghum from Manchuria as it did during the colonial period. As the government tried to collect its land tax in kind, the peasantry became even more reluctant to part with their rice. These factors persisted throughout the war, during which a rapidly increasing population and the concentration of more people in the south due to out-migration from the north greatly increased food demand. Finally, the government never made a commitment to develop agriculture, and even now yield and output increase mainly because of crop specialization and increased application of traditional inputs. These developments certainly influenced grain supply conditions enough to eliminate rice exports from South Korea,

but they hardly warrant being termed "modernization effects."

Finally, I would like to compare the Korean agricultural experience with that of Taiwan. Taiwan also exported agricultural products while under Japanese colonial rule and experienced a postwar land reform. But aside from the years 1945–50 agricultural exports increased in the postwar period [3, pp. 252–253]. Only in the late 1950's did the relative share of major agricultural commodities in exports begin to decline below their 1935–37 level [5, p. 27]. Like Korean farms in the colonial period, Taiwan family farms specialized and marketed rice and consumed inferior food, e.g., sweet potato, so that their marginal propensity to consume for rice also was high. In contrast to the Korean 1954–49 land reform, the 1949–52 land reform was effectively carried out and redistributed income considerably, but it did not influence family farm marketed surplus sufficiently to diminish primary product exports. I believe the reason for this was that already by 1951-52 the Nationalist government had successfully restored marketing channels between towns and villages, revived urban industry and commerce, and improved the terms of trade in favor of the peasantry. Thereafter the government invested in agriculture, and farms purchased new farming inputs so that yield and output increased sufficiently to supply enough food for the rapidly increasing population and yet produce a surplus for export.

The factors operating in both the short and long run to cause South Korea's rice exports did not operate with sufficient strength in Taiwan to reduce its primary product exports. The reason for this was that the economy rapidly recovered from the dislocations of the war and the departure of the Japanese; instead of war in 1949–50, the government rehabilitated the economy and adopted an enlightened policy toward agriculture. A recent study of rice marketing in four villages around Suwon city found that while 44 percent of rice output was consumed and the remainder marketed, the marketed surplus was positively correlated with farm size [1, part II]. As yields have only slowly risen after the war and gradual farm fragmentation continues, the marketed surplus of rice naturally has not increased very much. Korean farms simply have not yet experienced a seed-fertilizer revolution like that of Taiwan, so that yield per unit of land still has not risen dramatically. When such a revolution begins to take place in South Korea, there exists the distinct possibility that rice will again be exported in spite of continued farm fragmentation and population growth.

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"MODERNIZATION EFFECT" UPON EXPORTS OF AGRICULTURAL PRODUCE: SOUTH KOREA: REPLY

Professor Myers' comment gives me an opportunity to clarify a point that has been easily misunderstood.

Myers accepts my general proposition that "supply conditions rather than demand deficiency explains much better the post-1945 export lag of agricultural products from less developed countries." However, he doubts that income redistribution effect operated strongly in the 1945–49 period in South Korea. To support his assertion, he cites the fact that the land reform bill which passed the Korean Assembly in 1949 was not even implemented until the mid-1950's. The crux of his argument is that income redistribution effect on the order of magnitude I suggested in my article did not operate in the early postwar period because landlords continued to receive very high rents including "various gifts and payments from tenants."

It is true that the land reform bill did not pass until 1949. However, it is wrong to presume that things started to happen only after the bill was actually passed and implemented. On the contrary, even though the period from August 1945 to August 1948 was a period of inaction on the part of the government, it was a most revolutionary period as far as Korean land tenure was concerned, for it was during that time that the private land rights fell apart. It was then that tenants started defaulting on rental payments, and landlords no longer had strong political backing to collect rents. It was also in that period that the de facto government, which preceded the American military government, refused to enforce the private land rights.

Political and social conditions in that revolutionary period were also reflected in the fact that owning tenanted lands ceased to be a prestige factor.

Since most tenants defaulted on rental payments, buying a piece of land to lease was not a profitable investment; and in fact many landlords rushed to sell their lands at whatever price they could get. It is important to note, however, that the tenants who tilled the lands were the only potential buyers, since it was no longer possible to evict tenants. Furthermore, public opinion was overwhelmingly in favor of a sweeping land reform, and it was widely believed the "land-to-the-tillers" reform was just a matter of time. Thus, many events that occurred during that time had a drastic effect on land price, as shown in Table 1.

The mean price of one *chungbo* (2.45 acres) of rice land in the 1945–48 period was less than one-third of the annual production from the land. Most landlords, however, felt relieved if they succeeded in turning over their lands to the tenants at this low price, for they feared that their lands would be expropriated if they did not sell them then.

There had been a very active trading in the land market in the 1945–49 period. Out of about 1,400,000 *chungbo* of tenanted lands outstanding in 1945, 1,026,000 *chungbo* were already turned over to the tenants long before the formal land reform was carried out in the early 1950's. Thus, the formal passage of the land reform bill, or its implementation, was no more than an anticlimax.

What needs to be understood is the fact that during that revolutionary period, most tenants defaulted on rental payments. Of course, there were some exceptions. Rental payments then seldom reached 30 percent of annual production from the land—an amount that was the equivalent of the mean purchase price of the land—whereas in 1954 the new farm owners gave up about 30 percent for both repayment annuity and taxes. Hence, given the high marginal propensity to consume foods among Korean peasants, income redistribution effect upon exports of agricultural produce was particularly strong in the 1945–49 period.

Table 1. Mean price of one *chungbo*[a] of paddy land in Korea

Year	Mean price in *sok*[b] of rice
1935	62
1936	72
1937	77
1938	80
1945 (august)	7
1946 (June)	8
1947 (October)	6

[a] One *chungbo* is 2.45 acres.
[b] One *sok* is the equivalent of 5.119 U.S. bushels.
Source: The Bank of Korea, Department of Economic Research. Also see [1].

This income redistribution effect may explain to a large extent "the collapse of trade between towns and countryside" which Myers so astutely observed. Severe shortages of food in the towns during the period was a stubborn fact that seriously undermines Myers' second contention that "terms of trade turned severely against the peasant." This contention is handicapped further by the fact that terms of trade in the international markets turned in favor of agricultural produce in the period under consideration.

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A METHOD FOR ANALYZING THE EFFECT OF TAXES AND FINANCING ON INVESTMENT DECISIONS: COMMENT

The purpose of Rodewald's recent article [2] was to show how the effects of finance charges and taxes can be incorporated into investment decisions. Rodewald has fallen short of his objective in three ways:

(1) He has not considered the tax effects of depreciation charges that can shield substantial income from taxes.

(2) The formulas developed do not take into consideration any value that an asset may have at the end of the decision period (but salvage value is considered in determining after-tax capital gains).

(3) If capital gains or losses are anticipated, their effect is handled incorrectly; if capital losses should occur, the adjustment for taxes proposed by Rodewald is incorrect.

A second area of concern about Rodewald's paper is that the manner in which finance charges are included can lead to inconsistent decisions over time and may result in duplication of costs.

According to Rodewald's model, an investment is desirable when

$$I \leq V_0 = \sum_{t=1}^{k} \frac{E_0(Y_t)(1-T_r)}{(1+r)^t} - \sum_{t=1}^{i} \frac{C_t}{(1+r)^t} + \sum_{t=1}^{i} \frac{I_0}{(1+r)^t} + \frac{\left[I - \sum_{t=1}^{k} D_t - E_0(M_k)\right](1-Tc)}{(1+r)^t}$$

where

I = the investment cost;
V_0 = the value of the investment to the operator at t_0;
$E_0(Y_t)$ = the expectation at t_0 on income to be generated in t;
$E_0(M_k)$ = the expectation at t_0 on the value the market will generate for the asset in year k;
Tr = the tax rate used to compute the income tax liability;
T_c = the tax rate on capital gains;
C_t = the yearly financing charge;
I_c = the investment credit;
D_t = the annual amount of depreciation;
r = the rate used to discount expected income and market value;
t = unit of time;
k = the number of years the asset is expected to be used;
i = the number of years the credit is carried;
j = the number of years the payments are to run.

Depreciation is a noncash expense in the determination of a firm's tax liability. As such it shields a portion of before-tax earnings from tax payments. The tax shield provided by depreciation should be treated as a benefit that will accrue with a decision to invest in depreciable assets. The tax shield from depreciation charges can be incorporated by adding

$$\sum_{t=1}^{k} \frac{D_t}{(1+r)^t}(Tr)$$

to the right hand side of Rodewald's model.[1]

In his initial statement of the decision model, Rodewald included a term for the present value of any future market value that might exist at the end of a project. When he adjusted his model to include tax effects he omitted the term for future market value. This term, $E_0(M_k)/(1+r)^k$, should be part of the decision model.

The last term on the right hand side of Rodewald's model develops the present value after tax of any capital gains that might be expected at the termination of the project life for the investment. Since expectation of market value at the end of a project is considered in determining depreciation, projecting capital gains is a questionable procedure. If Rodewald's procedure is followed the portion of the term within brackets must be negative when there are capital gains. The sign in front of the term must also be negative if the present value after tax of capital gain is to be treated as a benefit. If capital losses were to occur the entire last term becomes meaningless, since capital losses are deducted from ordinary income (assuming there are no offsetting long-term gains, which would be the case when only one investment decision is under consideration).

The second term on the right hand side of Rodewald's model,

$$\sum_{t=1}^{j} \frac{C_t}{(1+r)^t},$$

develops the present value of financing charges. With this factor included, the desirability of an investment is dependent on the method of financing utilized. How an investment should be financed is a separate decision from the desirability of a proposal under study. As Bierman and Smidt suggest, a more serious problem of double counting arises when finance charges are included as part of the investment decision: "The interest factor is taken into consideration by the use of the present value procedures. To include also the cash disbursement for interest would result in double counting" [1, p. 114].

The decision model as adjusted in this comment would read as follows for the situation where straight-line depreciation is used and capital gains are anticipated:[2]

$$I \le V_0 = \sum_{t=1}^{k} \frac{E_0(Y_t)(1-Tr)}{(1+r)^t} - \left[I - \sum_{t=1}^{k} D_t - E_0(M_k)\right](1-Tc) + \frac{E_0(M_k)}{(1+r)^k} + \sum_{t=1}^{k} \frac{D_t}{(1+r)^t}(Tr).$$

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[1] This term assumes straight-line depreciation. The term would need adjustment with the use of accelerated depreciation and additional first-year depreciation.

[2] With the 1970 tax revisions, investment credit will no longer be allowed. Rodewald's term for investment credit,

$$\sum_{t=1}^{i} \frac{I_c}{(1+r)^t},$$

has been dropped from the formula.

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A METHOD FOR ANALYZING THE EFFECT OF TAXES AND FINANCING ON INVESTMENT DECISIONS: REPLY

I am grateful for the Devino comment, in particular on the capital gains and depreciation aspects of the model I proposed. He is of course correct in saying investment credit is no longer relevant. Other

of his comments need discussion. The basic decision model in question is as follows:

$$I \leq V_0 = \sum_{t=1}^{k} \frac{E_0(Y_t)(1-Tr)}{(1+r)^t} - \sum_{t=1}^{j} \frac{C_t}{(1+r)^t} + \sum_{t=1}^{i} \frac{I_c}{(1+r)^t} + \frac{\left[I - \sum_{t=1}^{k} D_t - E_0(M_k)\right](1-Tc)}{(1+r)^k}$$

where

I = the investment cost,
V_0 = the value of the investment to the operator at t_0,
$E_0(M_k)$ = the expectation at t_0 on the value the market will generate for the asset in year k.
$E_0(Y_t)$ = the expectation at t_0 on income to be generated in t,
Tr = the tax rate used to compute the income tax liability,
Tc = the tax rate on capital gains,
C_t = the yearly financing charges,
Ic = the investment credit,
r = the rate used to discount expected income and market value,
t = unit of time,
k = the number of years the asset is expected to be used,
i = the number of years the credit is carried,
j = the number of years the payments are to run.

Devino made three points explicitly and two implicitly:

(1) The tax effects of depreciation charges were ignored.
(2) The equation failed to take into consideration the end-of-period value.
(3) Capital gains and losses were incorrectly handled.
(4) Investment credit is no longer a relevant item to include.
(5) Including a finance charge in the equation leads to double counting.

For the first of these he suggests a method of handling depreciation tax benefits that should significantly improve the estimates of the tax effect. In response to the changes he proposes for handling points (2) and (3), rather than handle gains with a separate term I would suggest the following:

$$+\frac{E_0(M_k) - \left[E_0(M_k) - \left(I - \sum_{t=1}^{k} D_t\right)\right](Tc)}{(1+r)^k}.$$

The effect is to decrease the expected value by the amount of the capital gains tax. The error he pointed out was that the terms were not in the proper order, which made capital gains negative. In the above formulation the terms appear in the correct order, with Devino's suggested addition, and the sign is correct in all cases. No loss is recognized for tax purposes since in an expectation model of this sort it would seem to make little sense to say on one hand that $E_0(M_k) = \$5,000$ while on the other it is equal to \$17,000 in unrecovered depreciation. Either a loss is expected and is reflected in $E_0(M_k)$, or it is not expected and is so reflected. The objective in both situations would be to aid in determining a value for the minimum annual return required each year of the planning horizon to retire the investment. In either case, k indicated only the planning horizon of the decision maker. Projecting or anticipating a capital value different from the salvage value under these circumstances would seem to be a perfectly legitimate exercise when potential investments are being considered. Losses would show up as negative values for the expected market value and have the required influence on the value for the investment.

The point made by Devino concerning the interest charge is well taken. That is, the present value formulation does include a charge for interest as well as a charge for depreciation. However, if a firm or decision maker must borrow the money so that the interest charge is a cash expenditure each year of the finance period this charge must be included or the value of the investment may be seriously overestimated. These can be included in determining the cash flow or included as a part of the investment cost. To the extent that the economic life of most farm investments rarely coincide with the finance period, the method chosen in the Proceedings paper will allow for a somewhat more exact and easier method of computation. If the finance charge is added to the cost of the investment, these charges should not also be deducted from the cash flow, or double counting will result. If no borrowed money is used, the internal interest charge cannot be added to the investment cost or subtracted from the cash flow without double counting. The method chosen to include the finance charges may not be the best way to incorporate the charges, but I think it is necessary to recognize the consequences of these charges in investment evaluations.

Incorporating the Devino suggestions, the initial formula becomes

$$I \leq V_0 = \sum_{t=1}^{k} \frac{E_0(Y_t)(1-Tr) + D_t(Tr)}{(1+r)^t} - \sum_{t=1}^{j} \frac{C_t}{(1+r)^t} + \frac{E_0(M_k) - \left[E_0(M_k) - \left(I - \sum_{t=1}^{k} D_t\right)\right](Tc)}{(1+r)^k},$$

which will adequately evaluate the investment.

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RELEVANCE—WHERE DO YOU FIND IT?

In his note of last February, Ernest Grove concluded that the absence of disruption at the AAEA annual meeting in 1969 indicated that "the work of agricultural economists as portrayed and presented at the various sessions last August must be substantially relevant to today's problems and generally useful in dealing with them." Having concluded this "naturally and logically," Grove proceeds to question the "complete relevance of a meeting of agricultural economists in the State of Kentucky at which no mention was made of current problems of tobacco."

While I did not attend the annual meeting, I did thumb through the voluminous proceedings issue in the hope of garnering some morsel of useful information, substantive argumentation, pro or con, concerning current problems of American agriculture. After having done so I came naturally, and I think quite logically, to a conclusion the exact opposite of Grove's. I am not so brazen as to say that all of the papers were irrelevant and/or immaterial. I can't get by with a single exception to my conclusions as Grove did. There were perhaps a half-dozen papers which would, I believe, meet almost any basic test of timeliness and pertinence. Nevertheless, I can think of no instance in recent memory in which it appears that a quotation from Alexander Pope's *Essay on Criticism* could be more appropriate—to wit:

> "Words are like leaves; and where they
> most abound,
> Much fruit of sense beneath is rarely
> found."

Despite a vested interest, considerable training, and long experience in agricultural economics, I find the proceedings issues boring and most Journal papers alternately stuffy, dull, sometimes utterly pointless. If this assessment is accurate, what possible contribution can such writings make to the advancement or preservation of agricultural economics, much less to public enlightenment concerning American agriculture? Journal papers are not written for the general public, but the popularizing of a paper or idea should not be a chore equal to translating Greek or Latin into English.

If I were debating Grove on the subject of relevancy as an explanation for the lack of dramatics at the 1969 AAEA meeting, I would argue the con thusly: Grove's conclusion that the contributions of participants at the last convention must have been "substantially relevant to today's problems and generally useful in dealing with them" is mostly wishful thinking, if not sheer fantasy. An objective appraisal of the work of agricultural economists in the 1960's would, I believe, show the period to have been a rather sterile one. Perhaps it was too much of a contract-research decade—virtually all funded directly or indirectly by myriad Federal agencies. One cannot but wonder if such ballooning research, particularly at the universities, and efforts incident to the execution thereof has not, for the most part, reduced the majority of the profession—high and low—to a conglomerate mass of paper shufflers whose influence in decision making approximates that of office toadies. The lingering uncertainty about this applies only to the universities. At the Federal level, the question is scarcely moot. One by one (few of us really work as a group), our functions have been gradually and unceremoniously turned over, abandoned, or usurped by the political activists—sometimes PR men, lawyers, and/or management experts—whatever they are.

Thus, in stark contrast to Grove's conclusion, I conclude that the obvious indifference and absence of activist participants at the 1969 AAEA annual outing is explained by the fact that the activist element never heard of the organization and little, if anything, of the works of its members.

Over the past decade have we not, for the most part, been writing to and mainly for one another—exchanging drivel in the Journal and at the annual meetings? What real contribution did the profession make during the 60's to the maintenance of a strong and viable agriculture? Perhaps I have overreacted! If so, my timing is as timely as the phrase. Some would probably say, oh, haven't you heard about vertical integration, efficiencies of scale, and all those other advances we helped to promote? Don't you know that the cost of a pound of food in the United States requires only five minutes of the average wage earner's efforts? In contrast, it takes eight, ten, or maybe fifteen minutes in Lower Antarctica. This may sound impressive, but is it? So, in light of the record of the 1960's the question, arises: Why should activist planners—no, just activists—concern themselves with what the AAEA has been doing in recent years or is likely to be doing in the 70's?

For example, is it not true that for the past four or five years a groping, a search—battle, if you like—has been going on to come up with a new farm program, a national policy, for agriculture in the 1970's? I can think of only a half-dozen Journal papers in the past two or three years that relate to this subject, much less attempt to present useful ideas, guidance, or advice. Conceivably, I missed some good ones. The Shechter and Heady article "Response Surface Analysis and Simulation Models in Policy Choices" [2], is an interesting exercise for policy makers to ponder. I fear, however, that the title alone would most likely scare any policy maker rather than attract his attention.

I agree with Grove that relevance is "where it's at" and that we should each "do our own thing" but am in no way persuaded that the mere doing of one's own thing to the best of his or *her* ability is enough, be it advisor or aide-de-camp to the first, or more likely, the thirteenth vice-president in charge of tobacco sweepings, stored peanuts, or hops.

Cool rhetoric is a trademark of professionals and of professional journals, and it should not be otherwise.

Also, it may be well for those over 50 to leave any ideas about hell raising to graduate students and/or younger professionals. However, if the youthful element fails to mount the rostrum to do its thing for the AAEA and/or American agriculture, the older "silent majority" will have to come out of their comfortable (apparently) cocoons and do their thing. To youth, concede youth, nothing more.

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IRRELEVANCE IS WHERE YOU FIND IT: COMMENT

Grove [1] has commented on the number of disruptions that occurred at meetings of other professional associations, notably the American Psychological Association, the American Sociological Association, and the American Political Science Association, to name a few. The dissidents at these meetings were mainly graduate students and younger faculty members.

He viewed with a certain amount of satisfaction the fact that our annual meetings in Lexington were completely frictionless while everyone placidly viewed the scenery. Grove rather smugly concluded that the lack of disruption was due to the fact that the work of agricultural economists "must be substantially relevant to today's problems and generally useful in dealing with them." He then took the association to task for not including in its agenda Kentucky's tobacco problem.

I would like to offer four other possible reasons why our meetings were not disrupted. The first is logistic; unlike Rome, all roads do not lead to Lexington.

Secondly, being basically agrarian, the conservative background and upbringing of most of us would never allow such despicable activities. Our fondness for the status quo appreciably restricts any swift forward movement. I hope we never reach the point where we are so complacent that we cannot be critically introspective and make the necessary adjustments.

Thirdly, a weakness of many of the graduate programs in our profession is that an aggressive questioning of the system (be it the profession itself or wider in scope) as it exists is not encouraged, but rather stifled. If a misguided student or younger faculty member does question and does find problems in the system, he may be advised to do so quietly. We seem to be much less tolerant of "boat rockers" in our profession than in other professions. Granted, we turn out highly trained technical people, but are we turning out educated people? We seem to be producing technicians rather than thinkers. "Plug it in and crank it out" may well be the axiom of the day. As a result, our graduate students and younger faculty members may be too apathetic to protest. They may even be too apathetic to be interested.

Fourth, and finally, the relevancy of our work is open for debate. Perhaps our work is so irrelevant, it is not worth demonstrating against. Which is more relevant, the millions of people that have died from emphysema, hardening of the arteries, and heart disease (in 1969 alone 79,637 people in this country died from these ailments [3]) or the fact that half a million farmers (.025 percent of the U. S. population) may have to shift production to a less hazardous crop? Contemplate the grand paradox of government subsidies to tobacco producers at the same time that it bans cigarette commercials from television. Consider the inconsistency when we do not know the extent of malnutrition in the United States [2], but we do know how many pregnant sows are on farms. Consider the myriad of problems that exist in our economy, then tell me about the relevance of the tobacco problem.

Relevance is relative to the times, not to the individual.

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IRRELEVANCE IS WHERE YOU FIND IT: REPLY

Irony is a less-than-perfect weapon, as Dean Swift must *also* have discovered, for it sometimes seems to have missed its mark entirely.[1] Nevertheless, I welcome the evident misunderstanding by Crockett and Narrie, not only because it persuaded them to make

[1] Mine did not miss entirely. One reader told me, with obvious distaste, "You sure know how to stick needles in people."

some valid observations, but also because it affords me on opportunity to make explicit what I had previously tried to sneak across, so to speak: I felt that the program sessions at Lexington, with few exceptions,[2] were totally irrelevant to anything of importance in the real world.

Although both Crockett and Narrie have thus taken my remarks more seriously than intended and have reacted by castigating our profession, the former has done so from the standpoint of a long-term bureaucrat in agricultural economics, whereas the latter has apparently done so as a recent graduate student. It is remarkable, under these different circumstances, that the two viewpoints are so similar. I must have touched, however backhandedly, on a very sore point!

Both Crockett and Narrie have some good arguments and reach some valid conclusions in their respective areas, but I find myself in more agreement with Crockett than with Narrie. In fact, as a long-term bureaucrat myself, I agree wholeheartedly with almost everything Crockett says. I shall emphasize only one of his points, therefore, and then proceed to my disagreements with Narrie. Crockett laments the displacement of professional economists by management experts of various kinds. This is not new, for the "deprofessionalization of the USDA" has been referred to many times. It needs to be emphasized, nevertheless, because few in our profession are aware of the extent to which the current managerial cult, with its substitution of business management techniques for professional competence, has made inroads on the integrity of agricultural economics research.[3]

This is sometimes referred to as the "managerial revolution," but it is more a fashionable cult than a true revolution. Part of the problem lies in the too enthusiastic acceptance, by government and universities alike, of inappropriate business management techniques and standards. But in part these techniques and standards are themselves defective and therefore inappropriate even in the field of business management.[4] The result has been to make the management of government operations a real disaster area. Crockett seems inclined to exempt the universities from this indictment, but I cannot be so kind. Having been taken over by modern management types, our universities have become or are rapidly becoming "multiveristies," with all the connotations of inhumanity to man—and to students especially.

As to Narrie's four points, they elicit the following replies: 1. All roads do not lead to Lexington. Nevertheless, after the sedative effects of our annual meeting had worn off, the University of Kentucky experienced its full share of disruption. The lesson is clear: A representative democracy such as ours cannot fight a limited but lengthy war because, to soldier and citizen alike, the phrase "limited war" soon becomes a complete contradiction in terms. With no knowledge of what we are fighting for, even Kentucky students can set fire to the ROTC building—as they did after the Kent State affair.

2. We *are* complacent, and we have only just belatedly begun to make the necessary adjustments. Furthermore, I cannot accept the word "despicable" as descriptive of the activities engaged in by student militants. "Unprecedented," "annoying," "misguided," even "stupid"? Yes, possibly. But "despicable"? Emphatically no. I cannot despise courage of any kind, however displayed. And only those who have never tried it are unaware of the courage it takes to confront the establishment with unwelcome dissent.[5]

3. As to the character and quality of present-day graduate education, age must defer to youth in making this judgment[6]—yet I strongly suspect that Narrie has said things here that have long needed to be said. I would, however, question his concession with regard to "highly trained technical people." Most of these are "economagicians" specializing in numerical necromancy, a kind of divination from the entrails of misbegotten and stillborn statistical data.

4. The relevance of our work as agricultural economists is most certainly a legitimate subject for debate. But I disagree with Narrie in his implication that tobacco producers are negligible in number and therefore irrelevant. Relevance may be relative to the times, but individuals, as I said before, can only be relevant in their own areas of competence, usually small. And humanity is not served by the definition of relevance or importance solely in terms of numbers (cf. the parable of the lost sheep).

Let me illustrate this last point in terms of my own feelings and conclusions with regard to the current tobacco-health controversy. Furious objections to the use of tobacco on health grounds extend at least as far back in history as the "King James Counterblast," but somehow these furors have always blown over and the use of tobacco has continued and expanded. The real question, therefore, is whether the current controversy will subside, as all the rest, or whether a new and more lasting factor has been introduced into the tobacco situation.

[2] One notable exception was Bob Schwenger's paper on "New Concepts and Methods in Foreign Trade Negotiation," on pages 1338–49 of what is presumably, and hopefully, our last complete proceedings issue.

[3] A few agricultural economists ought to replace the "Think" signs on their desks with "Grovel" signs.

[4] The American Management Association has a lot to answer for—almost as much as the other AMA.

[5] I say "unwelcome dissent" because mild and innocuous disagreement, which constitutes no real threat to the in-group, may actually be welcomed as it provides a convenient facade of tolerance and "withitness."

[6] I no longer have any contacts at the graduate level. However, my son was in (and out of) a freshman dormitory facing Harvard Yard at the time of the takeover of University Hall, followed by the spectacular early morning bust. So I still have some considerable contact with undergraduate thinking and may be a bit "radicalized" myself as a consequence.

Personally, I think the latter is probably the case. Prior to the last half century, men simply did not live long enough for the ills now being blamed on tobacco to show up in their full force and effect. With the tremendous increase in longevity, however, it is now possible to get statistical samples that are truly "significant." And while absolute and incontrovertible proof, as demanded by the Tobacco Institute, is not yet forthcoming, the odds are now very high that tobacco will remain more or less under a cloud of controversy, if not full censure.

But this has grave implications for the future of tobacco producers and their price support program. I think there is a moral dilemma here, not in the health issue as such, but rather in its probable impact on the economic welfare of tobacco producers. These are effectively *locked in* on tobacco production by the price support program and its accompanying acreage allotment and acreage-poundage programs for cigarette tobaccos, at the same time that cigarette manufacturers are heavily engaged in diversification, taking the word "tobacco" out of their names, and otherwise maneuvering to avoid the consequences of the current health problem. It has even been rumored that cigarette companies are experimenting with marijuana cigarettes on the assumption that marijuana will eventually become legal![7]

Cigarette consumption in the United States started downward in the fall of 1967 and gives every indication of continuing on a downtrend, however slowly. The full impact of this situation has not yet been felt, but it is a dangerous one for producers of cigarette tobaccos, many of whom are still very small by present-day standards. The value of their production rights, now capitalized into the value of their allotment lands, might decline rapidly, to their great economic disadvantage. My conclusion, of course, is that the government should, promptly and generously, offer to buy up the acreage allotments or poundage quotas now outstanding on cigarette-type tobaccos. The values to be used in such a program should be those established in the rental market for production rights in flue-cured tobacco and should probably be the values in 1968, before the decline in consumption was recognized.

This would really cost money, perhaps as much as $3 billion,[8] and would fly directly in the face of the present administration's efforts to maintain a tight budget. For this reason, I would argue further that, if the government cannot afford to buy up these allotments all at once, it should nevertheless be willing to make a down payment, so to speak, by paying growers for any reductions in allotments they are required to make after 1970. This proposal is not likely to get anywhere, but I feel strongly that it should be made. Tobacco has always been the prime example of the capitalization of allotments into land values. At the present time, moreover, it also seems likely to be the first allotment crop in which the economic climate has changed so suddenly and so drastically that these allotment values will be lost, not gradually as has happened in some other crops such as cotton, but quite rapidly, perhaps in only two or three more years.

I trust this brief statement will convince Narrie and others that current problems of tobacco producers should seem highly relevant to concerned agricultural economists. (Are any of us concerned though? That is the question.)

ERNEST W. GROVE
Agricultural Stabilization and Conservation Service, USDA

[7] This has been firmly denied by the companies, but it might conceivably provide a new cash crop for midwestern farmers, who could then adopt another slogan—Permanent Pot Parity!

[8] The sum of $3 billion could be obtained most appropriately by setting aside Federal tax collections on cigagrettes for just 18 months! Total tax collections on all tobacco products—Federal, state, and local—amounted to $4.5 billion in fiscal 1970. The question arises: Who is being subsidized by whom?

IS THERE A BETTER WAY TO CHOOSE THE AAEA PRESIDENT?—COMMENT

There is another possible answer to the title question, one that Harold F. Breimyer apparently did not consider when he gave *his* answer [1]. This would be a sort of open primary, one year in advance. I think it is the best possible answer.

In addition to the form for suggesting names to the nominating committee for future consideration, there would be an actual primary ballot accompanying the current year's ballot. It should list all the names that the committee thinks should be taken seriously for the *coming* year's election, and members would be asked to vote for only two. The two winners would, except under extraordinary circumstances, be the candidates for president-elect in the following year, and their names would be announced whenever the regular election results were to be announced.

A defeated candidate should automatically have his name included in the primary ballot for the ensuing year. I have no fake sympathy for any person who has had the honor of running for AAEA president, even though he may have been defeated. Breimyer says that defeated candidates "are reluctant to expose themselves to rejection once again." All I can say is, "Nuts! Rejection is unavoidable in this life, and there are many more severe and more unfair forms of rejection than defeat in a democratic vote." And besides, under the proposed primary, the two nominees would have a year to bask in their

glory before one of them would have to accept defeat.

I agree with Breimyer that the nomination of more than two candidates is probably not a good idea. But I do not share his apparent faith in the "objectivity" (?!) of a selection committee, however chosen. I think the open primary, one year in advance, is well worth considering. The nominating committee could still function as a sort of umpire.

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Agricultural Stabilization and Conservation Service, USDA

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FAO-U.S. TRAINING CENTER IN CENSUS AND SAMPLE SURVEY PROCEDURES

Since 1967 an international training center has been operated in Washington, D. C., to provide officials, primarily from the less developed areas of the world, with the specialized skills needed to plan and carry out an agricultural census in their countries. FAO initiated the training program as a part of its sponsorship of a World Census of Agriculture under which it was hoped that all 122 members of the United Nations would conduct an agricultural census in or around 1970. The almost universal shortage of people experienced in census operations made it imperative that a comprehensive training program be undertaken. The result was the FAO-U.S. cooperative training project in Washington, which represents a joint effort of FAO, the Department of Commerce, AID, and the Department of Agriculture.[1]

The International Training Program in Washington begins in September; and the first nine months, divided into three periods, are devoted primarily to formal classroom instruction, seminars, and related work projects. Courses are given in statistical principles, sampling techniques, survey procedures, data processing, administrative practices, census methodology, and agricultural economics. Some 75 specialists from the Statistical Reporting Service, the Graduate School of the U.S. Department of Agriculture, and the Census Bureau participate in the training and lecture program.

The second phase consists of a six-week workshop in which detailed data, created for a mythical country called "Agrostan" are utilized for planning and carrying out an agricultural census. In this case study, all aspects of a census become involved, from initial planning through training, field operations, tabulation, and publication. Each participant is aided in relating the "Agrostan" project to his home country situation.

The third phase of the 12-month training involves the participants in an actual census and sample survey project. In the first year this phase was conducted with the cooperation of Washington State University and in the past two years with Pennsylvania State University, with the respective State agricultural statisticians participating. The trainees list the holdings in designated areas, select a sample, interview residents and farmers, edit the questionnaires, tabulate and analyze the results.

Now that many countries have completed their agricultural census, the emphasis in the training program is being shifted from census methodology to sample survey techniques designed to equip participants for the conduct of current sample surveys. This includes special instruction in procedures for making enumerative and objective yield surveys. There is a widespread and continuing need for such sample surveys, built upon the foundation of a census, that will provide dependable information concerning the agricultural economies of developing countries.

So far 144 participants from 59 countries have completed the Training Center Program and a new group started their training last September. Efforts are being made to continue the Training Center indefinitely in Washington for English-speaking participants.

HARRY C. TRELOGAN
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[1] A similar training project was conducted for French-speaking participants for nine months in Paris in 1968 but has not been repeated. Also, a three-month regional program has been conducted in South America, India, East Africa, and West Africa.

Reviews are listed alphabetically by authors.

Reviews

Armstrong, John Borden, *Factory Under the Elms: A History of Harrisville, New Hampshire, 1774–1969*, Cambridge, The MIT Press, 1969, xx + 320 pp. ($12.50)

This history of a small New England mill town is of some interest to economists and others concerned with economic development. The town's future is of likely greater interest. The economist may well speculate that more of a break with the past is in store and that such a break would not necessarily represent degeneration. The author has tried, with some success, to emphasize socioeconomic data and cannot be faulted for his zeal in pursuing these data in detail. The significance of this community, the author concludes, lies in its history of adapting to changing circumstances without destroying its past. The author's preface again points out that the town is somewhat atypical in that it "never became an industrial slum, a ghost town, or the fief of some outside industrial overlord."

Harrisville comes through as a successful company town. It owes its birth to a woolen mill established by the Harris family and its continued survival to decades of paternalistic guidance from the families of mill owners and managers. Housing, churches, schools and social life in the community have all received substantial sponsorship and guidance from these community leaders. Survival of the local mills required close management supervision—and this was given. It required producing a product for which there was a continuing demand—and the mills adapted their product accordingly. It required producing at competitive prices—and the mills did so, both by adopting the latest machinery, equipment, and processes, and by employing immigrants and others who were prepared to work for sufficiently low wages. Continuity of a reliable labor supply was assured by providing housing, both family housing and boarding houses for single employees, and by sponsoring other community facilities, including schools.

Enough is said in the closing pages to reinforce an economist's suspicions that Harrisville's prosperity in the next 30 years will depend on more explicit and more extensive economic and social interrelationships with neighboring communities. In this respect, Harrisville would be typical.

The 1960 population of the town was only 459, down from 748 in 1890. The remaining residents are "older now than the national average and older than was the town's population earlier in its history." The town now sends seventh and eighth graders, as well as all high school students, to school in Keene. And the remaining grades attend school in Chesham because a summer resident of Chesham contributed slightly more than half the cost of a new school. In 1950 this school was "one of the most modern schools in New Hampshire." A superhighway will soon slice through the outskirts of Harrisville. The author estimates that summer residents are now about double the number of permanent residents. Moreover, the summer residents are coming increasingly from New York, New Jersey, and other Middle Atlantic states; and many return for winter sports, while local residents increasingly winter in Florida.

In the light of these happenings, the author's espousal of the continued importance of the woolen mill may seem somewhat exaggerated and perhaps nostalgic:

> Central to both its prospect and its import is the woolen mill, standing symbolically where other New England towns have a common. The survival of the Cheshire Mills is of more than economic significance. Should the mill go under, the town would remain, but it would be at best another New England summer resort. It was the woolen mill of B. Harris and Company that fathered this community, and it is the same manufacturer that gives the town its identity today.

Alan R. Bird
Economic Research Service, USDA

Eicher, Carl K., and Carl Liedholm, eds., ***Growth and Development of the Nigerian Economy***, East Lansing, Michigan State University Press, 1970, vii + 456 pp. ($10.00)

Hill, Polly, ***Studies in Rural Capitalism in West Africa***, Cambridge, Cambridge University Press, 1970, xxviii + 172 pp. ($11.50)

These are welcome additions to the literature on African economies. Part of the contribution is in reprinting widely scattered articles, but both books—and Polly Hill's in particular—also provide new insights to the workings of the agricultural sector in African economies.

The book edited by Eicher and Liedholm takes in the entire Nigerian economy as its term of reference, but most of the growth and development discussed is agriculturally based. Polly Hill's book is specifically addressed to rural phenomena, particularly matters associated with capital accumulation in the rural areas of Nigeria and Ghana, areas that account for some 90 percent of the population of these countries.

Although Nigeria has already been the subject of much of the literatures on African economies, there is good reason for the amount of attention it gets. It is by a good margin the most populous country of tropical Africa. Although like all the countries of tropical Africa its population cannot at present be accurately measured, it appears to have somewhere between 50 and 70 million inhabitants, whereas few of the other forty-odd countries of tropical Africa have populations of over 10 million and many have populations fewer than four million. Nigeria is also of special interest because of the relatively recent discovery there of vast petroleum resources.

The volume edited by Eicher and Liedholm, the product of a 1968 summer workshop at Michigan State University, contains 21 chapters, 16 of which attempt to focus on economic changes in three overlapping periods: during the colonial period (roughly the last decade of the nineteenth century to 1961); between 1950 and 1962; and during the 1960's up to 1967. Another five chapters are devoted to speculation about the economic problems of the 1970's, speculations which, because the book went to press before the outcome of the civil war was known, are not infrequently based on assumptions that have turned to be incorrect.

Of the 21 chapters, 13 are original or revisions and the remaining eight are reprints. Of the original contributions, the chapters by Sara S. Berry on cocoa, J. S. Hogendorn on peanuts, Jerome C. Wells on agricultural planning, Malcom J. Purvis on the oil palm industry, and Scott R. Pearson on petroleum are especially noteworthy. Among reprinted papers are those of A. A. Ayida on supplier contracts, H. M. A. Onitiri on West African economic integration, Wolfgang Stopler on planning, K. D. S. Baldwin on the Mokwa scheme—one of the most dramatic of many African agricultural schemes that have been fiascos—and a paper by Gerald K. Helleiner on the fiscal role of marketing boards.

This is a useful book in bringing items worth reprinting together with related unpublished studies—including the cores of at least four dissertations not yet easily available—but it suffers from a lack of perspective that would have been provided had the editors included materials on precolonial economic history or had they made a more thorough search of the contemporary literature.

Hyla Myint's simple but demonstrably misleading vent-for-surplus model is the point of departure for the opening chapter by Carl Eicher on Nigerian agricultural history and it surfaces again in chapters by Purvis and Hogendorn. Critical to this model is the assumption that new cash crops can be produced with factors that otherwise would be idle, an assumption that appears to have grown more out of Myint's experience in densely populated areas of Asia than his knowledge of Africa.

By emphasizing the impact of access to new overseas markets and ignoring the overland export markets that West African economies have been involved in for as long as we have record, and by postulating idle resources although in fact we have little empirical evidence to support this assumption, as Sara Berry points out in her chapter, Myint's model makes it easy to think of rural African economies as stagnant until colonial powers evoked a surplus and provided a vent for it.

There is mounting evidence that many—perhaps most—of the rural economies of tropical Africa were far from stagnant in the precolonial period. New agricultural enterprises introduced in the colonial era were not the beginning of agricultural change as is often assumed, but merely the latest of several waves of crop introductions and changes in economic organization that date back to at least 1550 [1, ch. 3; 2, ch. 7; 3].

In summary, this book provides a limited, and in part misleading, introduction to Nigerian economic history and a useful sampling of some of the more important literature on government regulatory activity and economic planning in Nigeria. There is a conspicuous neglect of the present behavior of producers, traders, and consumers in rural Nigeria, the domain of Polly Hill's book.

Reporting on cocoa farmers, ocean fishermen, and cattle producers and traders in Ghana and the tobacco trade and inequalities in income and wealth in one area of northern Nigeria, Polly Hill sets out to show that economic activities in African rural economies are far more complex than has usually been thought and involve capital accumulation in ways heretofore largely ignored.

Five of the seven chapters are either reprints or draw heavily on her earlier work, but, especially since hers is the first serious attempt to explore capital accumulation by rural Africans, it is convenient to have this collection of studies under one cover.

The main criticism these essays will receive is that they are long on description and short on analysis. Chapter 5, particularly, on the cattle trade in northern Ghana, is replete with statistics that are of little relevance or, if relevant, only partly analyzed. Less important, but noticeable, are occasional misinterpretations of her data or failure to provide evidence to support critical points, as when discussing Ghanaian exports she states that "exports of palm produce did not fall significantly until cocoa growing had been established 20 years" without providing any evidence whatsoever (p. 24). It is also surprising that having specifically studied cocoa farming in Ghana and being especially interested in capital in rural economies she is content to generalize that the *abusa* sharecropping arrangement involves paying laborers one-third of the crop (p. 71). According to some of my Ghanaian informants, there are a variety of types of *abusa* arrangements, and laborers may receive as much as half of the crop if they provide some of the working capital needed. On the other hand, Polly Hill displays a rare skepticism of conventional wisdom about problems of development and has made impressively detailed studies of the economic activities she has worked on.

This clearly is a major contribution to the literature if for no other reason than that it strikingly changes our conceptual framework. Although it contains only a small sample of case studies from two West African countries, thinking about savings and investment in African rural economies will never again be the same.

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Hirshleifer, J., *Investment, Interest and Capital*, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1970, x + 320 pp. ($9.95)

Capital theory is a difficult and complex subject. A writer, especially one whose goal is in part synthesis, then, faces an inherently difficult task. Both the complexity of the topic and other reasons have led to certain matters being disputed in a polemical fashion.[1] Part of the controversies arise from the elementary problem that in the process of abstracting from the real world in order to analyze economic phenomena, two analysts may be asking different questions rather than getting different answers. An author whose goal is not to write the last word on the subject (which is not possible in any event), can sidestep much of the controversy by being consistent within whatever abstraction from the real world he adopts. Such is the case with the book here reviewed.

Investment, Interest and Capital is an outstanding textbook, and there is nothing pejorative in a book being called a text. Indeed, the author addresses the book to "the student" in the broadest sense. Hirshleifer has done a real service for any economist who is not a specialist in capital theory. He will also have in his debt all those graduate students who somehow have to summarize and unify a body of knowledge that they probably have been exposed to in a schizophrenic fashion. Aggregate investment is part of macroeconomics; capital accumulation is growth theory; the role of the rate of interest in allocating consumption over time, if taught at all, is part of microeconomics; and the optimal investment decision is part of something called capital budgeting that is taught in business schools. All of this and more, the author brings under one unifying theme.

The book's introductory chapter is a review of price theory in which the general equilibrium values of production, consumption, and price ratios are derived. As in the rest of the book, Hirshleifer uses three ways of expositing this theory: verbal reasoning, mathematical statements and derivations, and numerical examples. The examples are extremely helpful, especially as one progresses through the book. Everything that follows in Part I (two-thirds of the book) is an extension of this first chapter. The first extension is to make the objects of choice for which consumers maximize utility dated units of consumption. For these units the price ratios involve an interest rate as premium for current consumption. Hirshleifer then proceeds to discuss in turn: the optimal investment decision; market equilibrium, i.e., aggregate investment and interest; capital and accumulation; and imperfect funds markets. All of these topics are treated as involving a world of certainty. At the end of Part I the reader will have been exposed to a rigorous but lucid treatment of modern capital theory.

The author, however, goes even further. Part II relaxes the assumptions underlying Part I to allow intertemporal choices under uncertainty. Most readers will have to shift mental gears here. Before getting to the choices, a new set of preference functions must be mastered. In his usual clear fashion Hirshleifer lays out in Chapter 8 the theory of preference under uncertainty based on the Von Neumann and Morgenstern postulates of rational choice. Rather than dated consumption, the choice objects now are contingent consumption claims and, ultimately, dated contingent consumption claims. (His other terminology for the latter is time-state preference.)

These new objects of choice are then used to analyze investment under uncertainty. Now the author

[1] To see that the controversies are far from over, one need only consult Harcourt [1].

can discuss such things as degrees of riskness; incomplete markets, i.e., the inability to exchange all securities; and the type of financing to employ. Unfortunately, the time-state approach has not lent itself well to empirical work; and the author lastly takes up an alternative, the well-known portfolio selection theory in which the objects of choice are the mean and standard deviation of distributions of prospects.

It is to this material in Part II that the author expects, and rightly so, to see the most revision and addition. The relaxation of assumptions has proceeded from allowing time to enter through imperfect markets to uncertain prospects and incomplete markets. Complicated models are not apt to yield simple inferences. The complexities of Part II, however, should not obscure the beauty of Part I.

Hirshleifer's basic abstraction is Fisherian. The goal of economic activity is consumption. Intertemporal choice, then, is among dated consumption claims. A corollary allows consumption decisions to be separated from production decisions. A market rate of interest is then determinate and consistent with both sets of decisions. Whether this abstraction has serious implications for inferences back to the real world is still the subject of dispute. My hunch is that a Knightian quarrel with Hirshleifer's treatment would certainly be less severe than were some of the earlier discussions. Further, the author presents a lucid and straightforward presentation in Chapter 6 of the Knight and Bohm-Bawerk models of capital and accumulation.

An amazing amount of theory is covered in slightly over 300 pages. Some of the conciseness comes cheaply in that much of the material builds on previously discussed material. Some of it will come more dearly for the reader. He must be prepared to read the footnotes, study figures, and do some algebra. (Hirshleifer slips in and solves a simple calculus of variation problem on pages 94 and 95.) With this caveat I recommend the book to any "student" seriously interested in capital and interest. Anyone interested in benefit-cost analysis, capital budgeting, or any valuation-over-time problem can profit by a reading of Chapter 3 on the optimal investment decision.

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Reference

[1] HARCOURT, G. C., "Some Cambridge Controversies in the Theory of Capital," *J. Econ. Lit.* 7:369–405, June 1969.

Jones, E. L., and S. J. Woolf, eds. *Agrarian Change and Economic Development; The Historical Problems*, London, Methuen (New York, Barnes and Noble, distr.), 1969, xi + 172 pp. (£2; $6.50)

This volume of essays around a common theme results from a seminar held in Reading in the spring of 1968 but reflects only in part its proceedings. There are six independent case studies, with an introduction to set the common frame.

The essays are all competently done, but they are not all equally convincing. R. Zangheri writes with much erudition on Italy's problems of the late Middle Ages and the Renaissance, and for a moment he makes the reader believe that agricultural growth was strong enough so that it might have set off a breakthrough to an industrial society had it not been for the lack of political integration of Italy. How this would have been done before the invention of coking iron and steam power is not touched upon, nor is the core problem of rising industrial productivity in general.

F. M. L. Thompson, in an equally erudite piece on land ownership in England in the eighteenth century, arrives at arguing the developmental merits of landed-property concentration in a few hands on the ground that the landlords' tenant farmers were substantial enough men to buy manufactured goods, including some luxuries. This remarkable calculus eludes the fact that these substantial farmers were relatively few.

E. J. T. Collins, writing on labor supply and demand in European agriculture, 1800–1880, throws some very illuminating light on the mechanisms that made for adoption of early technical advances, such as the transition from sickle to scythe in grain harvesting.

R. P. Dore, in an article reprinted from *Economic Development and Cultural Change*, 1960, condenses some of the best insights on agricultural improvement in Japan, 1870–1914.

C. M. Elliott discourses on agricultural and economic development in Africa, 1880–1914: a very interesting exercise, loaded with relevant information and fresh viewpoints, but essentially (and admittedly) an exercise in rather little agrarian change and still less economic development.

Raymond Carr, discussing the Mexican agrarian reform, 1910–1960, still retains the long repeated and only quite recently refuted judgment of the *ejido* system as a brake on economic development.

The editors' introduction, a full-length essay in itself, tries to tie together some of the disparate strands in the case-study articles. Not as though they thought they had sufficient material for an advanced synthesis. A soberly critical spirit forbids any such extravagances. The editors also conclude on a rather pessimistic note, both as to the relevance of historical parallels from diverse epochs and on the prospects for speedy development of the present low-income countries. It seems to this reviewer that in drawing these conclusions, the writers have made both too much and too little of their evidence. Too much, for it does not sustain quite that much pessimism. Too little, for these immensely thorough

studies contain an impressive treasury of useful data. Agreed, historical analogies are not made of whole cloth, but piecemeal comparisons of partial processes will still give much material for systematic analyses. Agreed, too, that many of the present low-income countries lack much of the preparation that the early industrializers had used generations to achieve; but there are compensations in the speedier transfer of technology and in the higher initial productivity levels that are obtained in this way.

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Lewis, Stephen R. (Jr.), *Economic Policy and Industrial Growth in Pakistan*, Cambridge, The MIT Press, 1969, viii + 191 pp. ($8.95)

Stern, Joseph J., and Walter P. Falcon, *Growth and Development in Pakistan*, Cambridge, Harvard University Center for International Affairs, 1970, 94 pp. ($2.75 paper)

To a large extent these two books are complementary reading. The Stern and Falcon book is general in focus and presents a review of factors that have contributed to growth (or nongrowth) in Pakistan since partition and independence in 1947. Those not familiar with the history of Pakistan as well as the nature of the economy likely will find it useful to read this book first, if they are inclined to read both. It is relatively light and lucid reading, presenting only tabular data and offering general explanations or possible explanations of economic change and growth in Pakistan over the last twenty years. Lewis's book, on the other hand, is more analytical and analyzes changes in industrial composition and structure in a fair level of detail.

Neither of these books attempts to draw out any development principles from the Pakistan experience that would be useful for other countries; but then maybe none is appropriate. Stern and Falcon conclude that the Planning Commission has been a most significant factor in Pakistan's growth performance. Their conclusion follows from the fact that planning was initiated under the first five-year plan of 1955 when economic growth was virtually nil and that growth rose to over five percent per annum by the end of the second five-year plan (1960–65).

Lewis is not so generous in his appraisal of planning in Pakistan. Then he has no vested interest in this view. From his detailed analysis he concludes that the following nonpolicy factors were crucial to industrial development: (1) partition, which required Pakistan to transform itself from a supplier of food and raw materials for India in return for manufactured goods into a manufacturing country supplying a significant part of its own needs; (2) generous availability of agricultural raw materials, which could be and were used to manufacture goods for domestic consumption; (3) a relatively large mass market for consumer goods; and (4) relatively simple technologies that were available for producing them. Both books agree that import licenses and tariffs, which permitted manufacturers to obtain large profits that were in a large part ploughed back into industry, gave a tremendous boost to industrial development.

The policy of protection for "infant industries," Lewis concludes from his analysis, has paid off for Pakistan. Growth in "large" manufacturing industries has been near or much above 10 percent from partition through the Second Plan, and relative prices of some manufactured goods have declined. Moreover, some manufactured goods are now moving into export markets. However, domestic prices of many manufactured goods are still 100 percent above C.I.F. prices. Even so, it appears that a significant number of manufacturers today would remain viable under free trade policy.

Stern and Falcon allocate a significant part of their book to agriculture, which is only touched on in the Lewis book. But a relevant conclusion of Lewis is that some of the industrial growth took place at the expense of agriculture through a price policy that resulted in low prices for agricultural products and high prices for manufactured goods. Also, the policy to maintain an overvalued currency curtailed traditional agricultural exports.

But now, according to Stern and Falcon, agricultural development is well on its way, following a change of policy in 1959 to one that subsidizes agricultural inputs and guarantees high prices for grains. Their judgment, however, that Pakistan will shortly move from a food-deficient to a food-surplus position is, according to recent reports on agricultural output growth, likely to be wishful thinking for the present time.

All studies of economic growth seem to leave us with this question: Economic growth for whom and how fast? Pakistan still remains among the low per capita GNP countries of the world, less than $100 per capita despite rapid industrial growth. Agriculture still represents almost 50 percent of GNP. While the industrialists and, more recently, large farmers have become rich through policy programs, much of the general populace remains on the brink of existence. Unemployment has been estimated at 20 percent of the labor force. Underemployment, too, is very high. How to move the very-low-income countries such as Pakistan into developed countries in an acceptable time span is not answered in these books.

An interesting related study of Pakistan by Papanek [1] has this rather startling conclusion: Many of the early entrepreneurs who contributed to Pakistan's industrial development had very little formal education. Moreover, they were just as successful as most of the more highly educated businessmen. Good business sense apparently was gained through their tradesman background. They achieved success in business by contracting with foreign suppliers to set up plants, get them into production, and train personnel

to operate them. This seems to leave the best educational policy for development an open question.

Those interested in the details and some of the mechanics of growth will find that both of these books will help satisfy that interest.

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Reference

[1] PAPANEK, GUSTAV F., "The Industrial Entrepreneurs of Pakistan," *Development Digest* 8(3), July 1970.

Papi, Ugo, and Charles Nunn, eds., *Economic Problems of Agriculture in Industrial Societies: Proceedings of a Conference Held by the International Economic Association*, London, Macmillan, and New York, St. Martin's Press, 1969, xxix + 671 pp. ($21.00)

We have recently witnessed a proliferation of agricultural economics literature that deals with agriculture by focusing on sectoral interrelationships as opposed to a traditional preoccupation with intrasectoral relationships. Much of this literature has appeared in symposia or conference proceedings. The volume under review, which records the 1966 Rome Conference of the International Economic Association, joins a long and reputable list.[1]

A punctilious review of all 29 papers—let alone the discussion (at times endless) that follows each—might have been feasible but would have been unwise. The alternative is to discuss some of the papers by painting a few strokes of color in an otherwise impressionistic tableau, although by so doing the reviewer may at times appear to be arbitrary in this choice of the papers discussed and captious in his treatment.

E. A. G. Robinson (in an essay which, despite its title, has little to do with "The Desirable Level of Agriculture in the Advanced Industrial Countries") concentrates on some aspects of the familiar "developmental squeeze" of agriculture. He singles out three epochal innovations (to use Kuznets' term) that set in motion the economic pressures for the development of world agriculture. First is the improvement of ocean transportation, including refrigeration, which had already changed the character of competition in the European markets for food products before the end of the century. Second is the application of the internal combustion engine to farming. The advent of the era of mechanical agriculture ". . . released land, the scarce factor, from providing for the supply of horse-power in the most literal sense, to providing food either directly for human consumption or for feeding animals for human consumption" (p. 27). Third is the widespread use of chemical fertilizers and especially the improvements in seeds and pesticides. The influence of these epochal innovations is principally traced out in the case of the United Kingdom—a felicitous illustration of the proposition that agriculture is "at once inevitably subject to almost continuous economic pressure to adjust and also possessed of powerful influence to resist adjustment."

Glenn L. Johnson ("The Modern Family Farm and Its Problems: With Particular Reference to the United States of America") pursues further this proposition. His model emphasizes institutional arrangements that result in individual behavior that is not consistent with system rationality. Within that system Johnson explains both why family farms still exist in the United States and why larger than family farms face difficulties. "It appears that these [family farm] managers make mistakes of over-commitment [of resources in agriculture] *so rapidly* that production is maintained at levels *so high* that prices remain *so low* that larger than family farms have not been able to develop beyond the point where they have to compete in the open market simultaneously for both labor and capital" (p. 246). More generally, Johnson describes the economic pressures ("threats") together with the attempts to resist adjustment ("prerequisites of survival") of the family farm in the United States. The threats are technological advance, the availability of migratory workers to nonfamily-type farms, contract farming, integrated operations, and the problems of entering farming (including intergeneration transfer of ownership). The prerequisites for survival of the family farm include education and research, farmer cooperatives, adequate financing, and public policies designed to preserve the family farm (p. 242).

The discussion on farm size and family farms presented some brighter aspects in other papers. Ulf Renborg ("Tendencies Towards Concentration and Specialization in Agriculture") analyzes the effects of technological innovations on the size of farm and labor productivity and draws some interesting conclusions about the trends for the future. In the beginning of the 1960's small farms (less than 10 hectares) predominated in European agriculture—although a large part of the *arable area* was in farms larger than 10 hectares. The picture was not much different in the United States, where 29 percent of the farms were smaller than 50 acres with 6.5 percent under 10 acres. Furthermore, in the United States 43 percent of all farms had value of sales (in 1954 prices) under $2,500. In terms of employment the great majority of farms in Europe and the United States are large enough to fully employ one to two men. From the point of view of diffusion of technology at the small farm level, the author surmises from the study of Sweden that small farms are well in arrears of present technical potentialities (p. 214). That this is an unstable structure of agriculture is evidenced by a tendency for farms to increase in size, both in acreage and in sales per enterprise. Two conclusions emerge regarding prospects for the future: (1) a movement towards part-time farming as a half-way stop in the transition from farming to

[1] See list of references for some of these.

other occupations; (2) a tendency for the family farm to increase in land size in order to provide employment for one or two employees and to take fuller advantage of the processes of concentration, specialization, and integration.

A more optimistic appraisal of the performance and prospects of the family farm is provided by H. Priebe in "The Modern Family Farm and Its Problems: With Particular Reference to the Federal German Republic." Analysis of a sample of modern family farms in Germany suggests that returns to labor and capital are just as good on family farms as on larger farms. This relative success of family farms is not due to price protection; on the contrary, in Germany the price policy for grain and sugar beets has favored larger farms. Priebe concludes: "The requirements in farm management in a highly developed agriculture, especially, lead to the result that the independent small enterprise of the family farm has proved well suited to development and to the achievement of economic success" (p. 254).

The discussion that followed the slightly divergent views of Renborg and Priebe, as compared to the most pessimistic for the family farm views of Johnson, was lively. Nussbaumer (p. 275) suggested that the disagreement between "the middle European agricultural economists" and the others was due to the sociological importance that the former attach to the maintenance of the conservative family farm.

If the question of small versus large farms is purely a problem of ideological squabbling, it appears that the countries of Eastern Europe still have their share of it. In a stimulating paper, "Problems of the Re-Structuring of Agriculture in the Light of the Polish Experience," J. Tepicht offers a new insight into family farming from the vantage point of the socialist experience. The characteristic of family farming is the subordination of the lot of each individual to the general interest of the family unit. And the function of the peasant economy is to make the greatest possible use of marginal resources, especially of marginal family labor which is satisfied to work for "subnormal returns" as long as this employment means some increases in family income. At the present stage of the economic development in Poland (as well as in LDC's in general) where full employment of the labor force at "normal" wages is not feasible, the role of the family farm becomes crucial. Poland is trying to arrive at a socialist form of agriculture which, rather than being centered on the collective, would realize the advantages of vertical integration for a large number of peasant farms while giving them guarantees against being absorbed by the powerful integrating forces.

Czechoslovakia and Hungary, on the other hand, have gone the opposite direction in this ideological squabble: towards full collectivization. Besides a lackluster agricultural record in both countries, an immediately visible effect of the organization of society around industrial factories in the cities and state-owned factory farms in the countryside is mass exodus from agriculture. Villages have become dormitories for industrial workers. More than one-half of the labor force in agriculture are women and the rest are the aged (Joseph Flek, "Life and Income of Czechoslovak Cooperatives"; László Komló, "The Problems of Vertical Integration in Agriculture: The Hungarian Case").

The difference in emphasis on land tenure arrangements in Poland and in the other Eastern European countries has led to differences in the mechanics of farm integration and agricultural marketing. In Poland the contract system becomes the link between the agricultural units and nationalized industry (M. Pohorille, "Purchasing Contracts and Price Policy as Means of Planning Agricultural Production"). The contract system is simplicity itself, compared with the maze of arrangements that constitute the Russian agricultural marketing system; as an example, agricultural output is sold at "purchase prices" (collective farms), "fixed prices" (state farms), "retail prices minus a trade rebate," or "delivery prices fixed by local bodies on the basis of demand and supply analysis" (K. P. Obolenski, "Agricultural Planning in USSR").

The question of farm size is more than a question of agricultural politics. It is a binary mix of political philosophy and economic performance. Vernon W. Ruttan in an important paper ("Equity and Productivity Issues of Modern Agrarian Reform Legislation") looks at the philosophical and economic rationales of land reform. It appears that the two have led to antithetical policy objectives. Equity was the basic tenet of the political philosophy that led to owner-operated farms in the land reform experience of the United States, Western Europe, and Latin America; and of Japan, Korea, and Taiwan after World War II. Contrariwise, the objective of the land reform in England and in the USSR has been efficiency of production, and it has led to relatively large farm sizes. Perhaps a synthesis of the two objectives is appearing in the more recent land reform programs of Asia—in Malaysia, India, and the Philippines. Evidence has been accumulating that the owner-operated farm is not inefficient (and this reviewer would hazard the guess that it might be more efficient than the large farm within the mode of production of the chemical-biological agriculture). Ruttan submits the hypothesis that there is not a single optimum land tenure system. He concludes that analysis of land tenure policies on agricultural productivity should utilize a behavior model that accounts for the specific economic, technological, and socio-political environment of the country in question. One could not agree more.

Both agricultural protectionism and surpluses were discussed in earnest at the conference. Not surprisingly, it was found that agriculture "deserves" protection: because of the "specific" nature of agriculture, such as the purely competitive markets, the

"inevitability of technical and economic change which increases output per unit of labor," and the "fixity" of resources in agricultural production. As for surpluses, a battery of old and new tricks to deal with them was presented. Among the relatively old: Cochrane's proposal, which receives the major emphasis in Hathaway's paper ("The Search for New International Arragnements to Deal with the Agricultural Problems of Industrialized Countries"). Among the relatively new: the Common Market approach of establishing an "indicative price" (with an actual "intervention price" which is in general 5 to 10 percent lower) which is consolidated by a system of sliding duties, changed daily, the measure of which is equal to the difference between the world market price and the indicative price (Mario Bandini, "Free Trade and Planning in the Common Agricultural Policy," p. 81); deficiency payments (Mouton), which, predictably were rejected by the E. E. C. policy makers since it is one thing to apply the system in a country where agricultural population is 3 to 4 percent of the total—England—but quite another to apply it where the percentage is 30 to 40 of the total. It is not surprising that longing eyes turned towards exports and some kind of international cartelization to dispose of surpluses. D. J. Delivanis ("Problems Arising for the Agriculture of a Developing Country by Virtue of its Association with the European Economic Community") suggested the well-known problems of association in free trade markets of unequal and less developed partners. These countries, having lower productivity and higher costs, have serious difficulties in complying with indicative prices. But, "Should one not welcome the difficulties of farmers in marginal areas, as evidence of progress? Can the Greek economy . . . adapt itself to obtain a high level of economic activity, or will it be forced to restrict the progressive forces because of balance of payments difficulties?" (Robinson, p. 143). This was an anticlimatic admonition, especially coming after a long and sanctimonious discussion about the necessity and benefits of protection and price support programs for the marginal farmer of the United States and the European Economic Community!

The effects of agricultural protection and of surpluses of advanced countries upon trade and exports of less developed countries were too easily dismissed by J. H. Richter ("The Changing Patterns of International Trade Problems of Underdeveloped Areas") on the old—and incorrect—grounds that the main foreign exchange earners of underdeveloped countries are tropical exports. Be this as it may, the prospects for the exports of primary commodities of LDC's are rather disturbing, and therefore bleak is the picture of export-financed economic development. The paper by E. M. Ojala ("Agriculture in the World of 1975: General Picture of Trends") reported on the early projections of the FAO *Indicative World Plan,* and it should be read in conjunction with the more recent work by Louis F. Goreux (e.g., in Thorbecke [4]) and the Wicksell lectures by W. A. Lewis. Especially rewarding on this topic is the paper by V. Martinov ("The Changing Character of International Trade and the Problems of Under-Developed Regions").

Conference proceedings are often constituted of papers of spotty and uneven quality. This is a risk to which international conferences are especially exposed: The problems associated with the dynamics of conference organizing and "conferencing" are compounded with the problems of securing a truly international representation. This conference had its share of "those who also ran." In general, however, the problem of securing quality was rather successfully negotiated by the organizers of the conference. Evidence of this, additional to what has already been reported above, is that the conference also produced some of "those who ran too fast" for a cursory reviewer to be able to do them justice in the space he is allotted. Two examples will suffice: Yair Mundlak ("The Terms of Trade of Agriculture in Context of Economic Growth") and Nicholas Georgescu-Roegen ("Process in Farming Versus Process in Manufacturing: A Problem of Balanced Development"). The latter essay is especially provocative and merits a review of its own. I submit the title, "The Theory of Production and the Analytical Content of Agricultural Economics."

This reviewer thinks that the output and readability of future volumes of IEA conferences could be improved by eliminating the faithful, courtroom stenographic type of recording of each discussant's remarks, which at times are trivial or boring or unintelligible to the reader. An alternative format would be to assign a discussant to each paper whose responsibility would be to present an outline of a discussion paper at the conference and to prepare ex post a full discussion paper which incorporates the main points of the informal discussion that takes place at the meeting—to the extent that they are worth incorporating. It is not easy, but it is a feasible alternative.

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[2] SHAND, R. T., ed., *Agricultural Development in Asia,* Berkeley and Los Angeles, University of California Press, 1969.

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[4] THORBECKE, ERIK, ed., *The Role of Agriculture in Economic Development,* New York, Columbia University Press, 1969.

[5] WHARTON, CLIFTON R., ed., *Subsistence Agriculture and Economic Development,* Chicago, Aldine Publishing Company, 1969.

Richardson, Harry W., *Regional Economics; Location Theory, Urban Structure, Regional Change,* New York, Praeger Publishers, 1969, xii + 457 pp. ($10.00 cloth, $4.95 paper)

Richardson, Harry W., *Elements of Regional Economics,* Baltimore, Penguin Books, 1969, 166 pp. ($1.65 paper)

Those who were in vain looking for a single satisfactory volume on regional economics will receive Richardson's *Regional Economics*[1] with relief. This thick, complete, well-written, rigorous book can be used as the basic text for a graduate course, and parts of it can be used in an advanced undergraduate course. The book consists of three parts, with a balanced allocation of space to each one. Part A covers location theory in four chapters: spatial price theory, transport costs and location, optimal location of the firm, and the general theory of location. Part B is devoted to the economics of the city and contains information not readily available elsewhere to the economics student. In three chapters this part examines urban spatial structure, urban growth, and urban public economy in an interdisciplinary framework. Part C is a thorough presentation of regional macroeconomics; in terms of space it occupies one-half of the book. The author discusses the framework of regional macroeconomics, interregional income theory, regional business cycles, mobility of factors of production, regional growth, policy objectives and efficiency, and the strategy of regional policy.

Reviewers always find issues about which to disagree with authors and I am no exception to this rule. For the reader's sake I shall point out three misleading statements on substantive points.

In arguing for introduction of space into regional macroeconomic models, Richardson states that "we may further assume that the marginal propensity to import of each region is an inverse function of the level of regional income and that income is correlated with a region's size" (p. 272). The second part of this statement is neither obviously nor necessarily correct. What counts is the level of income, not just the size of a region. This however does not negate Richardson's suggestion for explicit introduction of space into regional macroeconomic models, since distance in the form of transport costs and lack of contact between markets affects interregional trade.

On page 409 Richardson argues that pecuniary moving costs may be a source of labor immobility. First, there is some evidence that moving costs are not substantial; second, if moving costs outweigh the expected gains, the existing earnings differences between labor markets do not indicate disequilibrium and thus no question of labor immobility arises. We suggest that it is probably the imperfection in the capital market (for financing migration) that is an impediment to labor mobility.

Again on the question of labor mobility, Richardson (p. 298) states his preference of probabilisitic models over deterministic ones. A probabilisitic model is in essence a gravity model and a deterministic model is one "... in which the rate of migration is determined by objective economic conditions, and individuals are treated as rational economic beings." Richardson's choice of model is a surprising one. In my opinion, gravity models are of limited usefulness as they offer no explanation of the observed human economic behavior. On the contrary, "deterministic" models are consistent with economic theory and when well-specified can do whatever a gravity model can do and more, and better. Parenthetically, one of the gravity models presented is Stouffer's 1940 model of migration and intervening opportunities, and no reference is given to Stouffer's later paper in which he modifies his earlier model [1].

Finally, there is a serious omission in the discussion of the effects of labor movements on the origin and destination of migration (pp. 394–397). Recent work shows that much of the effect depends on the capital-labor ratio of migrants as compared with the same ratio in origin and destination. Capital here includes both kinds, human and nonhuman. No discussion of this aspect of migration is found in the text.

In summary, despite my objections to some of Richardson's statements I find this book excellent and I wholeheartedly recommend it to those seriously interested in adding the space dimension into their stock of economic knowledge.

The second book, *Elements of Regional Economics,* is a short volume based on parts of the first book with a considerably narrower scope, but not a popular version of it. The word "Elements" in the title is not intended to show the depth of the book, but its limited scope. Material not contained in the first book include (1) some empirical evidence on the convergence of regional per capita incomes in Great Britain, (2) a section on the changes of the urban hierarchy in England, and (3) a section on the location-of-industry policy in Britain.

A short chapter is devoted to the presentation of some techniques used in regional planning. The discussions, however, are so brief that they do not allow the reader who is unfamiliar with these techniques to obtain any working knowledge of them or to develop a feeling of appreciation of their usefulness.

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[1] STOUFFER, SAMUEL A., "Intervening Opportunities and Competing Migrants," *J. Reg. Sci.* 2:1–26, Spring 1960.

[1] The same book with the same title was published in England in 1969 by Weindenfeld and Nicholson.

Sansom, Robert L., *The Economics of Insurgency in the Mekong Delta of Vietnam,* Cambridge, The M.I.T. Press, 1970, xviii + 283 pp. ($12.50)

Based on interviews in two villages in the Mekong Delta of Vietnam some 30 miles south of Saigon,

Robert L. Sansom has documented a "convincing case... for the economic rationality of the Vietnamese farmer" (p. 209). Sansom's analysis refers to the period in the mid-60's when strong demand forces for agricultural products were being felt. He shows how quickly and rationally the farmers responded to these opportunities, both by adopting production-increasing innovations for rice and by shifting to new crops. Much the most interesting part of his work are the interspersed vignettes of peasant farmer responsiveness. The invention and rapid dispersion of an impeller pump for low-lift irrigation is a classic example of economic response, peasant investment, and intermediate technology. His discussion of how peasants shifted to vegetable production with the development of new markets in Saigon is another example. Equally useful are his discussions of the impact of improved physical security and transportation on cropping patterns as road access was opened up; the spread of fertilizer even for subsistence production; and his conclusion that underemployment in Delta agriculture had previously existed, based on his analysis of small-farmer response to the growing labor demand of the 60's. His compact discussion of the village credit structure emphasizes the importance of unorganized money markets for peasant producers but also the impact of government-sponsored credit. Sansom concludes that the credit market was relatively open and that interest rates, although high, were "probably not a reflection of credit-market control" (p. 106). He finds landlords, moneylenders, and merchants unimportant in 1966 and shows that the predominant sources of credit were relatives, the government, and the *hui*—the revolving credit association of Chinese origin found with various modifications throughout Southeast Asia. (His description of the *hui* is detailed and lucid.) His analysis of the changing rice market illustrates how freeing a market can improve income distribution. Some household accounts would add to his discussion; and although he discusses peasant responsiveness in the production of draft animals, pigs, and chickens, why the curious omission of those flocks of ducks?

For Sansom, the villains of the piece are surely the landlords who were guilty of "widespread economic exploitation and social abuse" (p. 25). One cannot take exception to his concern nor to his demonstration that Viet Minh and later Viet Cong pressures led to a much more equitable land tenure structure, but one could ask for a discussion that probes more deeply into the tenure problem by seeing it in less simplistic terms. It is his black-and-white view of land tenure which is the most important weakness of his analysis, although he considers his treatment of land tenure as a key to his analytical framework (p. 5). He consistently underestimates the social, political, and economic role of the landlord (at least after 1930) and builds a picture of concentration and exploitation which is probably overstated. For example, he interprets the land tenure data for the 1946–67 period to mean that "at least 77 percent" of the farmers were tenants, whereas the data which he himself presents can equally well be summarized to show that 53 percent of the farmers owned at least part of the holdings they cultivated (p. 54). His interest in more equitable land tenure leads him to overstress Viet Cong concern for peasant welfare and understate its desire to eliminate landlords as an opposing political force in the countryside. (His simplistic view of the tenure problem also leads him to underestimate the concern of American officials about land tenure.) As a result, one learns less than he should from Sansom's analysis about the impact of economic environment and market forces on land tenure and their place as a complement to more direct measures leading toward his obviously desirable tenure goal.

The title of the book is misleading: It is a book about the economics of peasant farmers living in conditions of physical insecurity. Sansom does make one important observation about the economics of insurgency, however. He concludes that since markets ignore security conditions and peasants respond to price incentives even in an insecure environment, "in an insurgent war it should be the policy of the counterinsurgency effort to give aid to the inhabitants of the noncontrolled areas" in order to rob the insurgents of economic grievance issues (p. 244).

J. PRICE GITTINGER
Economic Development Institute, World Bank

Books for listing in this section should be sent to the Book Review Editor (see inside front cover for address).

Books Received

Barkin, David, and Timothy King, *Regional Economic Development: The River Basin Approach in Mexico,* New York, The Cambridge University Press, 1970, x + 262 pp. $10.50.

Boserup, Ester, *Woman's Role in Economic Development,* London, George Allen and Urwin Ltd., 1970, 283 pp. $9.95.

Bressler, Raymond G., Jr., and Richard A. King, *Markets, Prices, and Interregional Trade,* New York, John Wiley & Sons, Inc., 1970, xviii + 426 pp. $13.95.

Bunting, A. H., ed., *Change in Agriculture,* New York, Praeger Publishers, 1970, xiv + 813 pp. $27.50.

Campbell, Keith O., and Thomas E. Glau, *An Income Stabilization Scheme for the Wool Industry,* Sydney, Department of Agricultural Economics, 1970, vi + 62 pp. Paper.

Drache, Hiram M., *The Challenge of the Prairie; Life and Times of Red River Pioneers,* Fargo, North Dakota Institute for Regional Studies, 1970, xiii + 360 pp. $8.50.

Duckham, A. N. and G. B. Masefield, *Farming Systems of the World,* New York, Praeger Publishers, 1969, xviii + 542 pp. $21.50.

Food and Agriculture Organization of the United Nations, *Agricultural Development: A Review of FAO's Field Activities,* Rome, 1969, xii + 194 pp. $2.50 or 20s paper.

Food and Agriculture Organization of the United Nations, *A Strategy for Plenty: The Indicative World Plan for Agricultural Development,* Rome, 1970, viii + 63 pp. $1.50 or 12s paper.

Giles, Richard A., *Forced Rhubarb in the West Riding of Yorkshire,* Leeds, The University of Leeds, 1970, 76 pp. 10s paper.

Godwin, Marshall R., and Lonnie L. Jones, eds., *The Southern Rice Industry,* College Station, Texas A&M University Press, 1970, 222 pp. Price unknown.

Griffin, Keith, *Underdevelopment in Spanish America: An Interpretation,* Cambridge, The MIT Press, 1970, 288 pp. $10.00.

Hansen, Bent, *A Survey of General Equilibrium Systems,* New York, McGraw-Hill Book Company, 1970, xiii + 238 pp. $9.95.

Hildebrand, John Raymond, *Economic Development: A Latin American Emphasis,* Austin, The Pemberton Press, 1969, 153 pp. Price unknown. Paper.

Howard, H. W., *Genetics of the Potato: Solanum Tuberosum,* New York, Springer-Verlag New York Inc., 1970, ix + 126 pp. $8.60.

Huang, David S., *Regression and Econometric Methods,* New York, John Wiley & Sons, Inc., 1970, xiii + 274 pp. $12.95.

Hughes, Jonathan, *Industrialization and Economic History: Theses and Conjectures,* New York, McGraw-Hill Book Co., 1970, xii + 336 pp. $6.95 paper.

Institut National De La Recherche Agronomique, *Résumé Des Principales Recherches Du Département D'Économie Et De Sociologie Rurales,* Paris, Department of Economics and Rural Sociology, 1970, xii + 59 pp. Price unknown. Paper.

Iowa State University Center for Agricultural and Economic Development, *Benefits and Burdens of Rural Development,* Ames, The Iowa State University Press, 1970, xii + 311 pp. $5.95.

Laird, Roy D., and Betty A., *Soviet Communism and Agrarian Revolution,* Baltimore, Penguin Books Inc., 1970, 157 pp. $1.25 paper.

Langier, Jose David, *Economical and Nutritional Diets Using Scarce Resources,* East Lansing, MSU Division of Research, 1969, xv + 73 pp. $7.00.

Leven, Charles L., John B. Legler, and Perry Shapiro, *An Analytical Framework for Regional Development Policy,* Cambridge, The MIT Press, 1970, xi + 192 pp. $10.00.

Markham, Jesse W. and Gustav F. Papanek, eds., *Industrial Organization and Economic Development, In Honor of E. S. Mason,* Boston, Houghton Mifflin Company, 1970, xiii + 422 pp. $9.95.

McLoughlin, Peter F. M., ed., *African Food Production Systems: Cases and Theory,* Baltimore, The Johns Hopkins Press, 1970, x + 318 pp. $12.50 or 119s.

Meier, Gerald M., *Leading Issues in Economic Development: Studies in International Poverty,* 2nd ed., Stanford, Oxford University Press, 1964, xviii + 758 pp. $7.50.

Milner, Arthur Ross, *Grain Marketing: Pricing, Transporting,* Westerville, Ohio, West-Camp Press Inc., 1970, xvi + 287 pp. Price unknown.

Mitchell, Roger L., *Crop Growth and Culture,* Ames, The Iowa State University Press, 1970, viii + 349 pp. $9.50.

Mueller, Willard F., *A Primer on Monopoly and Competition,* New York, Random House, 1970, xi + 203 pp. $2.50 paper.

Myers, Ramon H., *The Chinese Peasant Economy: Agricultural Development in Hopei and Shantung, 1890–1949,* Cambridge, Harvard University Press, 1970, xix + 394 pp. $12.00.

Nanavati, Manilal B., and J. J. Anjaria, *The Indian Rural Problem,* 7th ed., Bombay, Vora & Co., Publishers Private Ltd., 1944, 622 pp. Rs 20.00.

National Farm Institute, *Corporate Farming and the Family Farm,* Ames, The Iowa State University Press, 1970, ix + 118 pp. $3.95.

Pouliquen, Louis Y., *Risk Analysis in Project Appraisal,* World Bank Occasional Papers Number Eleven, Baltimore, The Johns Hopkins Press, 1970, xi + 79 pp. $2.50 paper.

Preeg, Ernest H., *Traders and Diplomats,* Washington, D.C., The Brookings Institution, 1970, xiv + 320 pp. $6.75.

Richardson, Harry W., *Elements of Regional Economics,* Baltimore, Penguin Education, 1969, 166 pp. $1.65 paper.

Richardson, Harry W., *Regional Economics: Location Theory, Urban Structure, and Regional Change,* New York, Praeger Publishers, 1969, xii + 457 pp. $10.00.

Salaman, Redcliffe N., *The History and Social Influence of the Potato,* Cambridge, Cambridge University Press, 1949, reprinted 1970, xxiv + 685 pp. $22.50.

Sargent, E. D., and S. J. Rogers, eds., *The Economic Prospects for Horticulture: An Agricultural Adjustment Unit Symposium,* Edinburgh, Oliver & Boyd Ltd., 1970, xiii + 142 pp. £1.50.

Scott, A. D., ed., *Economics of Fisheries Management: A Symposium,* Vancouver, The University of British Columbia Institute of Animal Resource Ecology, 1970, vii + 115 pp. $5.00 paper.

Segal, Judith A., *Food for the Hungry: The Reluctant Society,* Baltimore, The Johns Hopkins Press, 1970, viii + 83 pp. $6.00 cloth, $1.95 paper.

Shen, T. H., *The Sino-American Joint Commission on Rural Reconstruction,* Ithaca, Cornell University Press, 1970, xiv + 278 pp. Price unknown.

Snodgrass, Milton M., and Luther T. Wallace, *Agriculture, Economics, and Growth,* 2nd ed., New York, Appleton-Century-Crofts, 1970, xiii + 489 pp. $8.95.

Taira, Koji, *Economic Development and the Labor Market in Japan,* New York, Columbia University Press, 1970, xiii + 282 pp. $10.00.

Taylor, Henry C., *Tarpleywick: A Century of Iowa Farming,* Ames, The Iowa State University Press, 1970, x + 134 pp. $4.95.

Tolley, G. S., ed., *Study of U. S. Agricultural Adjustments,* Raleigh, Agricultural Policy Institute, North Carolina State University, 1970, 319 pp. Price unknown.

Tweeten, Luther, *Foundations of Farm Policy,* Lincoln, University of Nebraska Press, 1970, xi + 537 pp. $9.50.

Williams, S. W., et al, *Organization and Competition in the Midwest Dairy Industries,* Ames, Iowa State University Press, 1970, xv + 339 pp. $12.50.

Winters, Donald L., *Henry Cantwell Wallace as Secretary of Agriculture/1921–1924,* Urbana, University of Illinois Press, 1970, x + 313 pp. $8.95.

Wish, John R., and Kelly M. Harrison, *Marketing—One Answer to Poverty: Food Marketing and Economic Development in Puerto Rico, 1950–65,* Eugene, University of Oregon Press, 1969, 191 pp. $5.00 paper.

Announcements

1971 AAEA ANNUAL MEETING

The 1971 annual meeting of the AAEA will be held on August 15–18 at Southern Illinois University, Carbondale, Illinois. Dr. Walter J. Mills, chairman of the Department of Agricultural Economics, is in charge of the local arrangements. Suggestions or requests, including needs for space for committee sessions to be held before or after the meeting should be addressed to Dr. Wills.

The program format for the annual meeting this year will follow the same general outline as that of 1970. Several seminar-type sessions will be organized for the afternoons around basic themes. Subsessions of these seminars will treat more specific topics for discussion purposes. One exception to the program of last year is that contributed papers sessions will be organized as part of the subsession treatment of the main seminar topics. Program organizers for the seminars will be asked to handle the contributed papers in their respective areas.

There will be a general coordinator of the contributed papers topics in order to ensure that the papers are expedited and treated properly. Dr. Charles E. French, chairman of the Department at Purdue University, will be the general coordinator.

Contributed papers will have to compete for time, therefore, with other subsessions of the seminars and with other topics of the annual program. They also will have to compete for time within the specific topical area to which they are designed, as it will be impossible to accept everything from everybody. Like all other subsessions and sectional papers, the contributed papers accepted will have to be abstracted in order to be printed in the Proceedings issue. These papers may, however, be submitted to the Journal in normal fashion as the basis for a complete article.

Information on contributed papers, as well as the other subject matter on the annual program, will be issued separately in a presidential newsletter or another communication to all members.

UNDERGRADUATE DEBATE, PUBLIC SPEAKING, AND ESSAY COMPETITIONS

Competition is open to any undergraduate student interested in agricultural economics. Participants are encouraged to become members of chartered student-section affiliates of the American Agricultural Economics Association, but such membership is not required to enter the various contests. No individual student may enter both the debate and the public speaking competitions in the same year.

Public Speaking Competition

The public speaking may be on any topic in the area of agricultural economics. Each speech will be limited to 10 minutes' duration.

Chartered chapters or individuals must declare their intention of participating in the public speaking competition by writing no later than June 1, 1971, to John Sjo, Chairman, AAEA Student Activities Committee, Department of Agricultural Economics, Kansas State University, Manhattan, Kansas 66502.

Debate Competition

The topic to be debated in 1971 will be announced directly to the departments.

A declaration of intention to participate in the debate competition must be made in writing no later than June 1, 1971, to John Sjo, at the address given above. Names of contestants and/or alternatives and coaches, along with the mailing address of each, should be included. No more than one debate team from one school may participate in the debate contest.

Student Essay Contest

The essay contest does not require attendance at our annual summer meeting. It was developed primarily to provide an opportunity to participate for students who find it impossible to attend the annual meeting and for students whose abilities and interest tend to be in research and/or writing. The development and preparation of a manuscript for purposes of publication is one of the objectives of this contest. Essays may deal with any topic in agricultural economics, agricultural industries, or rural sociology. The 1971 award paper will be published in the 1971 Proceedings issue.

Manuscripts should not exceed 2,500 words in length and should be prepared according to instructions appearing on the inside of the back cover of the *American Journal of Agricultural Economics.* Manuscripts must be submitted in triplicate by July 1, 1971, to Robert Beck, Department of Economics, University of Kentucky, Lexington, Kentucky 40506.

VISITING LECTURER PROGRAM IN STATISTICS

A Visiting Lecturer Program in Statistics is sponsored jointly by the principal statistical organizations in the United States, the American Statistical Association, the Biometric Society, and the Institute of Mathematical Statistics. Leading teachers and research workers in statistics—from universities, industry, and government—have agreed to participate as lecturers. Topics include subjects in experimental and theoretical statistics, probability theory, information theory, and stochastic models in the physical, biological, and social sciences.

The purpose of the program is to provide information to students and college faculty about the nature and scope of modern statistics and to provide advice about careers, graduate study, and college curricula in statistics. Inquiries should be addressed to: Visiting Lecturer Program in Statistics, Department of Statistics, Southern Methodist University, Dallas, Texas 75222.

FELLOWSHIPS IN FOREST RESOURCES

Harvard University announces Fellowships in Forest Resources with stipends up to $15,000 for research and advanced study, open to individuals in public service, academic careers, and private forestry. Inquiries should be addressed to: Committee on the Charles Bullard Fund for Forest Research, Littauer Center 119, Harvard University, Cambridge, Massachusetts 02138.

A NEW JOURNAL

The Southeastern Regional Science Association and the College of Business, Virginia Polytechnic Institute and State University, announce a new journal, *The Review of Regional Studies,* to be devoted to the study of contemporary regional problems—both urban and rural.

The Review is intended as a multidisciplinary forum for the presentation of major analytical and policy issues facing those interested in regional problems. It is hoped that *The Review* will attract as readers and contributors those interested in the solution of these problems. *The Review of Regional Studies* appears three times yearly—spring, fall, and winter. *The Review* is under the joint editorship of: Stanley E. Boyle, Virginia Polytechnic Institute and State University, and Robert T. Miki, Office of the Assistant Secretary of Commerce.

Manuscripts and business correspondence should be sent to: The Editors, *The Review of Regional Studies,* Department of Economics, College of Business, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

DUES

Dues for 1970 are payable. The dues rates are as follows:

Association	*Regular*	*Junior*
American Agricultural Economics Association	$15.00	$5.00*
Canadian Agricultural Economics Society	$10.00	$5.00*
Western Agricultural Economics Association	$ 3.50	$1.00*
Southern Agricultural Economics Association	$ 3.00	$1.50*
New England Agricultural Economics Council	$ 3.00	$1.00

* For graduate students, three-year maximum, approved by head of department.

Please mail your check, payable to AAEA or American Agricultural Economics Association, to John C. Redman, Secretary-Treasurer, AAEA, Department of Agricultural Economics, University of Kentucky, Lexington, Kentucky 40506.

News Notes

UNIVERSITY OF CALIFORNIA, BERKELEY

APPOINTMENTS: **Kenneth R. Farrell**, associate director of Giannini Foundation of Agricultural Economics, to develop and coordinate research and extension programs on a statewide basis; **Richard Norgaard**, Ph.D. candidate, Chicago, and **Ronald G. Loren**, Ph.D. candidate, Washington, acting assistant professors.

RESIGNATION: **Norman R. Collins**, to Ford Foundation as program officer in charge of Latin American agricultural programs.

UNIVERSITY OF CALIFORNIA, DAVIS

APPOINTMENT: **Thomas Dickinson**, Ph.D. Michigan State, assistant professor in Environmental Sciences Division.

LEAVE: **Jerry Foytik**, to participate in Education and World Affairs Program to improve teaching and research in Ethiopia, one year.

COLORADO STATE UNIVERSITY

APPOINTMENTS: **Quentin D. Banks**, formerly with Idaho Extension Service, and **R. Burnell Held**, joint appointment in Department of Recreation Resources and Department of Economics, professors; **Forrest E. Walters**, formerly with W. R. Grace and Company, and **Robert A. Young**, formerly with Resources for the Future, Inc., associate professors; **John S. Krebs**, assistant professor of geography.

LEAVES: **Rex D. Rehnberg**, ICA/AID University of Nebraska-MASUA program in Colombia, two years; **Donald D. Rohdy**, consultant to Dean of Agriculture, Virginia Polytechnic Institute, one year; **J. Hugh Winn**, Instituto Technologico Y De Estudios Superiores De Monterrey, Mexico, one year.

RETIREMENT: **C. Richard Creek**, associate professor, after 23 years of service.

CORNELL UNIVERSITY

APPOINTMENT: **Sanford A. Belden**, Ph.D. Purdue; Doyle A. Eiler, Ph.D. Oregon State; **Eddy L. LaDue**, Ph.D. Michigan State; assistant professors.

LEAVE: **Olan D. Forker**, USAID, Turkey, 1970–71.

ECONOMIC RESEARCH SERVICE, USDA

(EDD is Economic Development Division; ESAD is Economic and Statistical Analysis Division; FPED is Farm Production and Economics Division; FRAD is Foreign Regional Analysis Division; MED is Marketing Economics Division; NRED is Natural Resource Economics Division.)

APPOINTMENTS: **Joseph W. Willett**, formerly deputy director, FRAD, director; **Harry E. Walters**, formerly leader of Community Areas Analysis Section, FRAD, deputy director; **Andrew Anton Duymovic**, **John Feaster**, and **Michael P. Steiner**, MED, Washington, D.C.; **Peter Ashton**, NRED, Berkeley, California; **John Baritell**, MED, Pullman, Washington; **Wayne A. Boutwell**, MED, Blacksburg, Virginia; **Herrington J. Bryce**, Brookings Fellow, EDD, one year; **Arthur L. Coffing**, Africa and Middle East Branch, FRAD, Washington, D.C.; **Ivery D. Clifton**, FPED, Washington, D.C.; **Reed E. Friend**, formerly leader of Demand and Competition Section, Europe and Soviet Union Branch, FRAD, assistant branch chief, Far East and Oceanic Branch; **Nancy Hancock** and **Lorin Lovfald**, Far East and Oceanic Branch, FRAD, Washington, D.C.; **John David Hanson**, MED, Ames, Iowa; **Paul L. Holm** and **John R. Schaub**, staff assistants to Administrator; **Philip L. Mackie**, formerly with Foreign Agricultural Service, Europe and Soviet Branch, FRAD; **Ronald L. Mighell**, chief of Production Resources Branch, FPED, Washington, D.C.; **Thomas Twomey**, formerly transportation economist, Far East and Oceanic Branch, FRAD, Washington, D.C.

TRANSFERS: **Walter Armbruster**, MED, from Corvallis, Oregon, to Washington, D.C.; **John Berry**, FPED, from Urbana, Illinois, to Washington, D.C., as chief, Production Resources Branch; **William G. Bursch**, FPED, from Urbana, Illinois, to Lafayette, Indiana; **A. Barry Carr**, FPED, from Stillwater, Oklahoma, to Washington, D.C.; **Donald Chrisler**, FRAD, from Office of the Director to Communist Areas Analysis Section; **Cecil W. Davidson**, FPED, from Washington, D.C., to Urbana, Illinois; **Sam Donald**, EDD, from Washington, D.C., to Alcorn, Mississippi; **Walter Epps**, and **Masao Matsumoto**, from MED to EDD, Washington, D.C.; **Richard Fallert**, MED, from Washington, D.C., to Lafayette, Indiana; **Richard Greenhaigh**, NRED, from Little Rock, Arkansas,

to Columbia, Missouri; **Anthony Grano,** NRED, from Corvallis, Washington, to Office of the Director, Washington, D.C.; **Gerald Horner,** NRED, from Pullman, Washington, to Davis, California; **Edward Jesse,** MED, from Madison, Wisconsin, to Washington, D.C.; **James B. Johnson,** FPED, from Corvallis, Oregon, to East Lansing, Michigan; **Norman Kimball,** NRED, from Madison, Wisconsin, to Berkeley, California; **Mack Leath,** MED, from Stillwater, Oklahoma; **Dudley Mattson,** NRED, from Pullman, Washington, to Washington, D.C.; **Gerald O'Mara,** MED, from Raleigh, North Carolina, to College Park, Maryland; **Melvin D. Skold,** formerly associate professor of economics, Colorado State University, head of the Western Field Research Group, FPED, Fort Collins, Colorado, and professor affiliate, Colorado State University; **Gordon Rodewald,** FPED, from Washington, D.C., to Pullman, Washington; **Otto Thieman,** NRED, from Pullman, Washington, to Little Rock, Arkansas; **Paul Velde,** MED, from Lafayette, Indiana, to Washington, D.C.; **James Vertrees,** MED, from East Lansing, Michigan, to Washington, D.C.; **Virgil L. Whetzel,** NRED, from Land Resources Group to Northeast Resources Group at West Virginia University; **Gaylord Worden,** FPED, from Ames, Iowa, to Washington, D.C.

LEAVES: **Lynn Bickley,** FRAD, to teach in Pakistan; **Robert E. Freeman,** EDD, to teach at Chico State College, Chico, California; **Michael E. Kurtzig,** FRAD, on detail to Foreign Economics Development Service to work on a management training program for high-level Turkish agriculturalists; **Walter Miller,** NRED, to Federal City College, Washington, D.C., one year.

RESIGNATIONS: **Richard A. Benson,** FPED, to accept position in Peoria, Illinois; **Donald A. Carr,** FPED, to accept position at Sacramento State College, Sacramento, California; **Neville Doherty,** EDD, to staff of Health Center (University of Connecticut), Hartford, Connecticut; **Robert R. Fletcher,** NRED, Stillwater, Oklahoma, to Wyoming Agricultural Experiment Station, Laramie; **John M. Himmelberg,** ESAD, to Government Accounting Office; **Richard M. Kennedy,** FRAD, to be USDA coordinator at Virginia State College; **Burl Long,** NRED, University Park, Pennsylvania, to Virginia Polytechnic Institute; **Lyle E. Moe,** FRAD, to Foreign Agricultural Service as assistant agricultural attache in New Delhi; **Roger E. Neitz,** FRAD, to Foreign Agricultural Service as assistant agricultural attache in Bonn; **Robert L. Rizek,** ESAD, to be director, Consumer and Food Economics Division, Agricultural Research Service.

RETIREMENT: **Merton S. Parsons,** FPED, after 33 years of Federal service.

AWARDS: **E. W. S. Calkins,** MED, American Society for Testing and Materials Award of Merit; **Robert V. Enochian,** Western Regional Research Laboratory, Certificate of Merit.

UNIVERSITY OF FLORIDA

APPOINTMENTS: **Carlton G. Davis,** Ph.D. Michigan State, assistant professor with assignment in Guyana under AID-University of Florida contract; **Robert D. Emerson,** Ph.D. Purdue, assistant professor in labor economics; **Gary F. Fairchild,** Ph.D. Texas A&M, assistant professor and research economist with Florida Department of Citrus; **Edna T. Loehman,** Ph.D. Purdue, assistant professor in resource economics.

LEAVE: **Harold B. Clark,** to assist in grain marketing in Indonesia, five months.

AWARDS AND HONORS: **Kenneth R. Tefertiller,** Southern Agricultural Economics Association president, 1971.

UNIVERSITY OF GEORGIA

APPOINTMENT: **Raul E. Yver,** Ph.D. Chicago, temporary assistant professor.

LEAVE: **L. Harlan Davis,** Brazil, as deputy chief, Planning and Development, ARDO, USAID.

IOWA STATE UNIVERSITY

APPOINTMENTS: **Ronald E. Raikes,** assistant professor; **Larry D. Bedford, Brent W. Spaulding,** and **Patricia A. Coffey,** instructors; **Roger A. Norem,** instructor and associate; **Stanley H. Hargrove** and **Uma K. Sirivastova,** research associates.

LEAVE: **Wallace Ogg,** faculty improvement leave, six months.

LOUISIANA STATE UNIVERSITY

APPOINTMENTS: **R. Bruce Johnson,** Ph.D. Missouri, assistant professor; **Robert C. Nelson,** M.S. Louisiana State, instructor.

LEAVE: **Bill Bolton,** South Vietnam, as member of USDA team with USAID to perform an agricultural sector analysis for the Republic of South Vietnam.

AWARDS: **W. H. Alexander,** Associated Milk Producers, Inc. Distinguished Service Award; **E. P. Roy,** L.S.U. Foundation Distinguished Faculty Fellowship Award.

MICHIGAN STATE UNIVERSITY

APPOINTMENTS: **Harold Riley,** USAID mission, Bogota, Colombia, one year; **Lawrence W. Witt,** USAID, Washington, D.C., one year; **Paul Nelson,** U. S. Department of Agriculture, and **Rainer Schickele,** Agricultural Development Council, visiting professors, six months; **Lawrence W. Libby,** Ph.D. Cornell, assistant professor.

RETIREMENT: **Arthur Mauch,** after 32 years of Federal service.

UNIVERSITY OF MINNESOTA

APPOINTMENTS: **Harald R. Jensen**, acting department head, succeeding **Vernon W. Ruttan**, now director of the Economic Development Center; **Malcolm J. Purvis**, Party Chief, Minnesota-Tunisia Project under AID-University of Minnesota contract; **Jerome W. Hammond**, two-year assignment with Minnesota-Tunisia Project under AID-University of Minnesota contract; **Emiel W. Owens**, formerly of Prairie View A&M College, and **Adolf O. Weber**, University of Kiel, Federal Republic of Germany, visiting professors; **John A. Speicher**, Michigan State University, visiting associate professor; **Jonathan D. Anderson**, M.S. North Dakota State; **William E. Griffiths**, Ph.D. Minnesota; and **James E. Hamilton**, research specialists.

LEAVES: **Reynold P. Dahl**, returned from three-year assignment as Party Chief, Minnesota-Tunisia Project; **W. Keith Bryant**, visiting professor and visiting staff economist, Institute of Research on Poverty, University of Wisconsin; **Charles H. Cuykendall**, Cornell University.

RESIGNATION: **Lyndell W. Fitzgerald**, to Food and Agriculture Organization of the United Nations, Rome.

UNIVERSITY OF MISSOURI

APPOINTMENT: **Francis McCamley**, formerly of Kansas State University, assistant professor.

AWARD: **Donald Levi**, Alumni-Faculty Gold Medal Award for teaching, work with students, and alumni-faculty relationships.

NEW MEXICO STATE UNIVERSITY

APPOINTMENTS: **James Gray**, acting head of department, one year; **Stephen W. Fuller**, Ph.D. Kansas State, and **Alan J. Randall**, Ph.D. Oregon State, faculty.

LEAVE: **George R. Dawson**, sabbatical, Cooperative State Research Service, Washington, D.C., one year.

NORTH DAKOTA STATE UNIVERSITY

APPOINTMENTS: **F. Larry Leistritz**, Ph.D. Nebraska, assistant professor in production economics and farm management; **Delmer L. Helgeson**, Ph.D. Nebraska, associate professor in rural and community development.

OHIO STATE UNIVERSITY

APPOINTMENTS: **S. S. Johl**, Punjab Agricultural University, Ludhiana, India, visiting professor until August 30, 1971; **Dick Thomas**, formerly associate professor, associate state leader, Community and Natural Resource Development; **Terry Glover**, Ph.D. Purdue; **Donald Larson**, Ph.D. Michigan State; **Ted Napier**, Ph.D. Ohio State; **Donald Thomas**, Ph.D. Pennsylvania State; assistant professors.

LEAVES: **Kelso Wessel**, returned from two-year assignment in Brazil as member of ESALQ/OSU team; **Richard Meyer**, Sao Paulo, Brazil, two-year assignment with USAID to work on OSU Capital Formation Project.

AWARD: **Wallace Barr**, USDA Superior Service Award.

RETIREMENT: **Ross Milner**, as professor of agricultural economics and rural economics, July 1970.

RESIGNATION: **John S. Bottum**, to be Assistant Administrator, Rural Development, Extension Service, U. S. Department of Agriculture.

OKLAHOMA STATE UNIVERSITY

APPOINTMENT: **Alan R. Tubbs**, Ph.D. Cornell, assistant professor.

RESIGNATION: **Leonard F. Miller**, to Rockefeller Foundation, University of Ibadan, Nigeria.

OREGON STATE UNIVERSITY

APPOINTMENT: **Timothy Hammonds**, Ph.D. Cornell, assistant professor in marketing and price analysis.

LEAVES: **Grant E. Blanch**, sabbatical; **Leon Garoian**, Agricultural Extension Service, University of California, Berkeley, one year; **Albert N. Halter**, Michigan State University, Fall and Winter quarters, 1970–71, working on Nigerian simulation project; **Gary Seevers**, President's Council of Economic Advisors, 1970–71, as senior economist.

AWARD: **Emery Castle**, Distinguished Professor Award, by Oregon State University Alumni Association.

UNIVERSITY OF RHODE ISLAND

APPOINTMENTS: **Bruce W. Mattox**, Ph.D. Oregon State, and **Edmond E. Seay, Jr.**, Ph.D. Iowa, assistant professors in resource economics.

SOUTH DAKOTA STATE UNIVERSITY

APPOINTMENTS: **William F. Payne, Jr.**, Ph.D. Oregon State, and **Jacob E. Wiebe**, Ph.D. Tennessee, staff.

SOUTHERN ILLINOIS UNIVERSITY

APPOINTMENT: **Gordon Honegger**, Ph.D. Purdue, assistant professor.

LEAVE: **Walter J. Wills**, returned from leave at Ege University in Izmir, Turkey, upon death of Herman Haag, to replace him as local chairman for the 1971 AAEA annual meetings at Southern Illinois University and to resume chairmanship of the department.

TEXAS A&M UNIVERSITY

APPOINTMENTS: **John A. Hopkin**, formerly of the University of Illinois, first Stiles Foundation Professor of the College of Agriculture; **Don Mathews**, formerly of Doane's Agri-Service, extension area farm management specialist; **Phi**

Eckert, formerly with USDA, extension economist working with Texas Agricultural Market Research and Development Center of Texas A&M University.

LEAVE: **C. R. Houston,** returned from assignment as Chief of Party for Texas A&M University-USAID Project in Argentina, 1964–1970.

WASHINGTON STATE UNIVERSITY

APPOINTMENTS: **Gerald W. Huettig** and **Richard W. Johns,** associates in research.

WEST VIRGINIA UNIVERSITY

APPOINTMENTS: **Dale K. Colyer,** formerly of the University of Missouri, professor; **Kenneth J. Hock,** assistant professor; **Alfred Barr,** professor of agricultural economics, director of Division of Animal and Veterinary Sciences.

LEAVE: **Ernest J. Nesius,** assistant director in the Office of Domestic Production, USAID, Vietnam.

UNIVERSITY OF WYOMING

APPOINTMENT: **Robert R. Fletcher,** Ph.D. Oklahoma State, assistant professor and extension marketing specialist.

LEAVE: **Rollo L. Ehrich,** returned from two-year assignment as advisor to graduate students and consultant to National Institute of Agricultural Technology, Argentina.

OTHER APPOINTMENTS

Lester L. Arnold, formerly assistant director, Production Credit Service, Farm Credit Administration, vice-president, Federal Intermediate Credit Bank, Louisville, Kentucky.

Richard F. Bieker, Ph.D. Kentucky, assistant professor, University of Delaware.

Ronnie L. Burke, Ph.D. Minnesota, Center for Community Development and Research, Glenville State College, Glenville, West Virginia.

Giorgio Cingolani, Ph.D. California, researcher, Einaudi Foundation, Torino, Italy.

Paul Gessman, Ph.D. Cornell, assistant professor of resource development, University of Nebraska.

Frank M. Goode, Ph.D. Minnesota, assistant professor, University of Tennessee.

R. Clyde Greer, Ph.D. Minnesota, assistant professor, Montana State University.

Charles Edward Harshbarger, formerly of the University of Missouri, Federal Reserve Bank of Kansas City.

John Helmuth, Ph.D. Missouri, Ft. McNair, to teach economics for the military service.

Roger P. Hill, formerly of the University of Georgia, professor of economics at the University of North Carolina.

Gerald W. Huettig, associate in research, Washington State University.

D. Raymond Humberd, Ph.D. Kentucky, assistant agricultural economist, University of Tennessee.

Richard W. Johns, associate in research, Washington State University.

Donald MacLaren, Ph.D. Cornell, faculty, University of Aberdeen, Scotland.

T. David McCullough, Ph.D. Cornell, research, Armour & Co., Chicago.

Richard G. Milk, assistant professor of economics, College of Business Administration, Northeast Louisiana University.

Rodrigo Mujica, Ph.D. California, assistant professor of agricultural economics, statistics, and economics, Catholic University, Santiago, Chile.

Max Myers, South Dakota University, President's Commission on International Trade and Investment Policy.

Glenn Nelson, Bureau of Higher Education, Department of Education, State of Michigan.

Gerald M. Nolte, Ph.D. Minnesota, assistant professor, Wisconsin State University.

Douglass G. Norvell, assistant professor of economics, University of Tampa.

Brian Payne, Ph.D. California, research forester-economist, Northeastern Forest Experiment Station, USDA Forest Service, Amherst, Massachusetts.

Kenneth E. Ogren, formerly agricultural attache, U.S. Delegation to OECD, Paris, staff, President's Commission on International Trade and Investment Policy, Washington, D.C.

M. Ziller Rahman, M.S. Michigan State, Planning and Development Department, Government of Pakistan.

William R. Reilly, Ph.D. Purdue, chairman, Department of Economics and Business Administration, Norwich University, Northfield, Vermont.

Lowell Wood, Ph.D. California, assistant professor of agricultural economics and chairman of the department, Brigham Young University.

Tae-Hee Yoon, formerly senior economist, Dominion Bureau of Statistics, Government of Canada, agricultural economist, International Bank for Reconstruction and Development, Washington, D.C.

OTHER LEAVES

Alfred G. Harms, University of Illinois, Njala University College, Sierra Leone, West Africa, two years.

John W. Wysong, University of Maryland, to study profitability of improvements in grassland and forage handling in Yugoslavia and the United Kingdom, 1970–71.

OTHER AWARDS AND HONORS

Russell H. Brannon, University of Kentucky, AAEA international travel grant to attend IAAE meetings in Minsk, Russia.

W. F. Musgrave, University of New England, Armidale, N.S.W., Australia, editor, Australian Journal of Agricultural Economics, succeeding **J. L. Dillon** of the same institution.

OBITUARIES

Jere R. Boyer, associate extension specialist in food distribution at the University of Hawaii, died in September 1970. Jere was born in Topeka, Kansas, on January 26, 1933. At an early age he moved to Tucson, where he earned his B.S. and M.S. degrees from the University of Arizona. He would have received his Ph.D. degree from the University of Hawaii in 1971.

Jere worked as an extension specialist in New Mexico for three years before going to Hawaii in 1962. He was well known as a consultant in supermarket operations and made numerous trips to Japan, where he instructed Japanese market operators in management techniques.

John Chester Ellickson, who retired in May 1965 from the Farm Production Economics Division of the U. S. Department of Agriculture, Washington, D.C., died in August 1970.

Wells A. Hutchins, a nationally recognized authority on Western water laws, had completed over 62 years of service with the Department of Agriculture at the time of his death in Berkeley, California, in September 1970. Mr. Hutchins began his government career in 1908, with the Department of Agriculture's Bureau of Soils. His service in the Department included the Office of Extension Service, Office of Public Roads and Rural Engineering, Bureau of Public Roads, Bureau of Agricultural Engineering, Soil Conservation Service, and Economic Research Service. The Department gave recognition to his accomplishments with the Superior Service Award and the Outstanding Performance rating.

After reaching retirement age in 1958, following nearly 50 years of Federal service, Mr. Hutchins was reemployed each year so that he could complete his important book on the law of water rights in the western states.

Hutchins' *Selected Problems in the Law of Water Rights in the West* has been a classic in its field since 1942. His work included studies of water law of California, Hawaii, Nevada, New Mexico, Oklahoma, Idaho, Kansas, Montana, Texas, and Utah. He helped many states draw up improved water laws and in the 1940's served as chairman of National Reclamation Association's committee to formulate desirable water law principles for the West. He also lectured on water law and institutions at the University of California at Davis and Berkeley. He was made a life member of the National Reclamation Association and received many other honors for his knowledge and accomplishments in the field of water rights.

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Agricultural Credit in Latin America: A Critical Review of External Funding Policy*

DALE W ADAMS

During the 1960's aid agencies channelled over one billion dollars to agricultural credit systems in Latin America. This plus local funds boosted the real value of rural credit by 12 percent per year. A number of assumptions underlying past credit policy are critically examined. It is argued that currently credit shortage is not the most pressing issue. Rather, emphasis should be placed on realistic pricing of rural credit and mobilizing rural savings for credit use through interest incentives.

DURING THE 1960's resources for credit made up a large part of externally funded agricultural programs in Latin America. In the ten years 1960 to 1969 the Agency for International Development (AID), the Inter-American Development Bank (IDB), and the World Bank Group (IBRD) provided dollar assistance for agricultural credit worth approximately $915 million in Latin America.[1] IDB made the largest contribution with $439 million, IBRD was next with $255 million, and AID followed with $221 million. Over half of AID's total direct assistance to agriculture in Latin America has gone into credit activities. In addition to this direct assistance, AID has helped channel to agricultural credit institutions several hundred million dollars worth of "counterpart funds" and "local currencies" resulting from program loans and Public Law 480 sales [26]. This has been especially important in Brazil, Colombia, and Chile.

The bulk of the assistance to agricultural credit systems provided by AID and IBRD has gone to Latin America. During the 60's this included all but 10 percent of AID's loans and grants for this purpose and approximately three-quarters of IBRD's loans.

Most countries in Latin America have received substantial credit assistance. Mexico leads with 177 million dollars; Brazil, Colombia, and Argentina follow with 122, 114, and 101 million dollars, respectively. Several of the smaller countries have also received large amounts of external assistance for this purpose: Costa Rica ($30 million), Nicaragua ($45 million), and Paraguay ($37 million). Most AID and IDB loans for agricultural credit have given the borrowing country concessional arrangements: low interest rates, grace periods, and long intervals for repayment.

Despite the emphasis on credit in Latin America, little attention has been focused on the economics of these activities; and very little careful evaluation of these programs has been done. The main intent of the following discussion, therefore, is to evaluate several of the major assumptions that underlie current agricultural credit policy. I tentatively question some of these assumptions in the hope of stimulating further analysis of this topic and suggest several changes which might improve the overall performance of these programs.

Policy Assumptions

Although generalization is somewhat difficult, several common assumptions can be noted in the agricultural credit programs in Latin America:

(1) Credit shortage is one of the major bottlenecks causing low land and labor productivity in traditional agriculture. Not only does a current shortage of production credit exist, but the future transformation of less-developed agriculture will also require major credit infusions.

(2) Concessional lending arrangements for farm credit are justified because: (a) farmers have been exploited by lenders who charge ex-

* Part of the material used in this study was assembled while the author was employed by the Agency for International Development (AID). Additional resources were provided by an AID-funded research project on capital formation and technological change. Charles Blankstein, Kenneth Fedor, Alexis Lachman, J. K. McDermott, Richard Newberg, Stanley Please, Judith Tendler, Philip Warnken, and associates at The Ohio State University, as well as reviewers and editors of the Journal gave helpful suggestions regarding the study.

[1] This information was drawn from AID's "Annual Reports on Capital Assistance and Technical Assistance Projects" (W-253), for June 1969; from various unpublished worksheets of AID's Latin American Bureau; and from various annual reports of the Inter-American Development Bank, International Bank for Reconstruction and Development, and the International Development Association.

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orbitant rates of interest; (b) most traditional farmers need special inducement to use highly productive inputs for which credit is necessary; (c) low interest rates are further justified as an income transfer mechanism and/or to offset fiscal or pricing policy that adversely affects farmers.

(3) Little savings capacity exists in rural areas, and marginal propensities to save are low. Almost all funds for credit, therefore, must come from outside the agricultural sector.

Given the emphasis placed on agricultural credit programs, it is disturbing to find very little evidence to confirm these vital policy assumptions. Several of these assertions are questionable, and alternative suppositions should be seriously explored. Unfortunately, with the existing lack of economic research on credit in Latin America, a discussion of this subject must be more suggestive than conclusive.

Agricultural Credit Shortage?

Several different types of information have been used to suggest that a serious shortage of agricultural credit exists in Latin America [30]. The most prominent of these have been: (1) the fact that large amounts of external funds have recently been absorbed by the agricultural credit systems; (2) comparative data showing that countries in Latin America have substantially less agricultural credit than developed countries; (3) the impression that high interest rates in the informal credit market indicate a shortage of credit; (4) the apparent insatiable demand at the farm level for agricultural credit; and (5) the knowledge that technological change in agriculture, which is occurring in parts of Latin America, has a high credit propensity.

Credit absorption

Institutional agricultural credit in the 18 countries analyzed has expanded in real terms rather rapidly, averaging an increase of 12 percent per year over the period 1960 to 1967–68 (see Appendix).[2] Since inflation in some countries has eroded a significant part of the real value of credit funds, this growth is even more remarkable [12]. In 1967–1968, about 4.7 billion dollars worth of agricultural credit was in force in these countries.[3] Parenthetically, this was approximately the amount of farm credit in force in the U. S. Lake States of Michigan, Wisconsin, and Minnesota at the close of 1967 [57].

Even with this sharp increase in availability of credit, institutional funds in almost all countries have not covered total loan requests, and in this sense agricultural credit is clearly still short. Since rather low rates of interest are often charged on these loans, it is unclear whether rates of interest closer to the marginal efficiency of capital would still result in excess demand.

Comparative data

Some evidence on the relative availability of credit in Latin America is shown by comparing the value of institutional agricultural credit with the value of agricultural output (GDP). Ratios for these values are presented in the Appendix (column 4). For comparison purposes, several similar ratios for the United States and Taiwan may be useful. In the United States, for example, total credit for agriculture amounted to over $53 billion at the beginning of 1969 [57]. Since very little institutional credit is available in Latin America for land purchases, it is probably more relevant to remove real estate credit from this figure and use only the amount loaned for rural production and/or consumption—$25.3 billion. Comparing this figure with total gross value of agricultural output in the United States in 1968—$47.6 billion—results in a ratio of .53 [58]. In Taiwan total institutional agricultural credit amounted to about 15.6 billion new Taiwanese dollars in 1969.[4] The gross value of agricultural production in the same year was 39.5 billion new Taiwanese dollars.[5] The ratio of total credit to product was therefore .39.

Agricultural credit in 18 Latin American countries in 1967–1968 was equal to a little over one-third of the aggregate value of total agricultural production in the region (see Appendix). Chile, Costa Rica, Mexico, Nicaragua, and Venezuela all had agricultural credit equal to or greater than half their value of agricultural production. Bolivia, Ecuador, Guatemala, Honduras, Panama, and Uruguay, on

[2] It will be argued later that noninstitutional or informal agricultural credit in Latin America is relatively unimportant.

[3] Care must be used in interpreting absolute values of agricultural credit funds in Latin America. The choice of deflators and exchange rates is very important. Also, in some countries funds used for financing exports of agricultural goods, intermediate market sales of goods, and nonagricultural activities may be classified as agricultural credit. In addition, in several countries loans in default may be a significant part of the total portfolio, e.g., Peru and Venezuela.

[4] Unpublished data from the Farmers' Bank of China.

[5] Unpublished data from the Department of Agriculture and Forestry, Provincial Government of Taiwan.

the other hand, had ratios of credit to output of .15 or less in 1967 or 1968. One might argue that low ratios in a number of these countries are economically justified because subsistence agriculture makes up a large part of the agricultural sector, e.g., Bolivia, Ecuador, Guatemala, Honduras, and possibly Panama. At best, these credit-to-output ratios present a mixed case for agricultural credit shortage in Latin America.

Column 3 in the Appendix presents ratios of agricultural credit to total domestic credit. Bolivia, Brazil, the Dominican Republic, Ecuador, Honduras, and Mexico have substantially increased the share of total credit received by agriculture over the 1960 to 1967–68 period. Colombia, El Salvador, Guatemala, Nicaragua, and Uruguay, on the other hand, have decreased agriculture's credit share. Costa Rica, Mexico, and Nicaragua have very high ratios in this regard; Ecuador, Guatemala, Panama, and Uruguay have surprisingly low ratios, As in the case of the credit-to-output ratios, these agricultural credit-to-total-domestic-credit ratios do not give conclusive evidence on the credit shortage issue. They do indicate, however, that Latin America may not be too badly off with almost one-third of total credit allotted to agriculture.

Interestingly, tests of significance on rank-order and product-moment correlation coefficients relating average annual rates of growth in institutional credit and average annual rates of growth in gross domestic product from agriculture suggest no dependency. The lack of relationship between growth in agricultural credit and agricultural output may be due to time-lag questions or to leakage of credit funds away from agricultural production purposes.

Characteristics of informal credit market

Characteristics of the informal credit system are occasionally cited as supporting the agricultural credit shortage claim.[6] Evidence appears to be rather inconclusive, however, with regard to Latin America. A review of studies on informal credit systems shows that most of the wisdom on this topic stems from experience in Asia [59, 62]. It has been usually held, for example, that private individuals, money lenders, merchants, etc., provide a large part of total rural credit in less-developed areas. In India, for example, studies have shown that less than 20 percent of total rural credit is furnished by the formal credit system [42]. In Thailand only 5 percent of the agricultural credit was reported coming from institutional lenders [53].

Less comprehensive data on several Latin American countries suggest a much smaller role for informal credit. In Ecuador, Stitzlein found only about 10 percent of the total credit used by about 1,000 farmers was supplied by noninstitutional sources [49]. Two-thirds of the farms in his sample had less than 20 hectares, and only about half of the farmers surveyed used credit. Erven found even less noninstitutional credit in southern Brazil [17]. He surveyed 233 commercial crop and hay farms and found that only 3 percent of their total agricultural credit came from noninstitutional sources. In the same general area of Brazil, but among small farm operators, Rask and Rao found only one-third of total farm credit used by 200 small farmers came from noninstitutional sources [41]. Nisbet's study of informal rural credit in Chile showed that noninstitutional credit made up only a little over one-tenth of total credit among the farmers he surveyed [35, p. 170]. Tinnermeier also found that noninstitutional farm credit was not significant among almost 200 farmers in a colonization area of Colombia [54]. Montero likewise found noninstitutional credit to be insignificant for 239 farmers he interviewed in a major agricultural region of Colombia [31]. Although noninstitutional loans made up about one-quarter of the number of loans held by these farmers over a four-year period, they equalled less than 4 percent of total funds borrowed. Anthropological studies by Nash and Tax of Indian communities in Central America showed that institutional credit was almost totally lacking, but they also found that only very modest amounts of noninstitutional credit were used [33, 50]. Likewise, a study in Costa Rica of 320 farms in 1964–1965 showed that only 20 percent of total credit used by these farms was provided by the informal credit system [13].

If these studies are representative, they suggest that the amount of noninstitutional credit in rural areas of Latin America is not very sizable. If there is a large segment of economically justified demand for agricultural credit, the noninstitutional money markets apparently have not exploited the opportunity. One could ask, "Does the lack of a sizable informal credit system indicate a deficiency in effective demand?"

High interest rates in the informal credit

[6] "Informal credit system" is here used to mean credit provided outside the banking system and officially sponsored development or cooperative programs.

market also have been cited as indicating credit shortage. That is, demand pressures face a small pool of loanable funds embodied in a highly inelastic supply schedule. It is therefore concluded that competition for these funds has driven interest rates up and resulted in monopoly profits for owners of loanable funds [59, p. 80].

Again, a review of various studies of interest rates charged in the informal credit markets in rural Latin America strongly suggests that interest rates at best are weak indicators of production credit shortage. It may be that the importance of extremely high rates of interest in the informal credit markets in Latin America has been greatly overstated. For example, Nisbet showed that in Chile a majority of the loans made within the informal credit system which he studied were lent at zero or negative real rates of interest [34]. Stitzlein showed that an average annual nominal rate of interest of less than 20 percent was charged on noninstitutional loans among the farmers he studied in Ecuador, and over 40 percent of the noninstitutional loans in his study carried no interest charge [49].[7]

Another aspect of this question is that relatively high rates of interest may be justified on loans in the informal credit market. The bulk of these loans are small, short-term, unsecured, and mostly for consumption, and lenders' administrative costs are therefore high [4]. Similar loans in developed countries also carry relatively high rates of interest. Moreover, these rates may be justified because of the high opportunity cost of capital in developing countries, lenders' risks, and the substantial rates of inflation that are common in a number of Latin American countries [5, 6]. There is very little evidence available to substantiate extensive monopoly profits in the informal credit market [3, 48].

In conclusion, an analysis of informal credit in Latin America does not present firm proof that a significant shortage of production credit exists in the rural areas. It may well be that these informal credit markets are not large because of the lack of demand for their services and strong institutional competition. It is also apparent that the high-interest-rate problem has been oversold and that current interest rates charged in this market may be rather modest, considering the nature of the services rendered. It may well be that current noninstitutional credit is supplying a market that is largely unrelated to the market for productive agricultural inputs. Thus, marginal costs for credit in this market may be of little or no value in determining the marginal productivity of capital used for agricultural inputs.

Strong demand for institutional credit

Throughout Latin America agricultural credit requests often substantially exceed available funds. From this it has been concluded that a good many economically justified loans are not made because of credit shortage. But, as already suggested, it has also been common to grant credit to farmers at concessional rates of interest. In Colombia, for example, most institutional agricultural credit has been loaned at rates of interest within the range of 7 to 13 percent. Borrowers of capital in the nonagricultural sector, however, pay from 18 to 25 percent for their funds. Hardly a country in Latin America does not have similar arrangements. If the marginal opportunity costs of capital in the country are in the general range of the charges on credit that nonagriculturalists are willing to pay, it is not surprising that agricultural credit is so popular.

Inflation is a further reason for the strong demand for institutional agricultural credit. During the period 1961–1968, six of the Latin American countries experienced average rates of inflation in excess of 10 percent per year—Argentina, Brazil, Chile, Colombia, Peru, and Uruguay. These countries, in turn, extended almost 60 percent of the agricultural credit in Latin America during 1967–1968. During the 1960's a major portion of the institutional agricultural credit in these countries was lent at real rates of interest that were negative; that is, nominal rates of interest were less than monetary depreciation. It is little wonder, then, that borrowers have clamored for negatively priced agricultural credit. Without an adjustment to efficiency prices, it is difficult to determine the economic effectiveness of this strong demand for credit.

On-farm capital formation and new technology requires credit

Again, it has been rather widely held that large doses of credit are necessary to facilitate rapid on-farm capital formation and technological change in agriculture. This view has

[7] Lending by merchants for specific purchases may mask the real charges associated with the lending. Purchase price adjustments may substitute for interest as payment for use of capital. None of the studies available on Latin America explored this in any great detail, however.

been challenged recently by some who argue that development of appropriate new technology must precede expansion of the credit system and that technology may have a low credit propensity [21]. While it is apparent that technological barriers are important in a number of situations, under some circumstances credit can be the leading edge of technological-change policy. Rao has correctly pointed out, for example, that agricultural problems tend to be heterogeneous and that uniform policy prescriptions are often not appropriate [40]. In a study of farms in southern Brazil he found that similar-sized livestock ranches and crop farms had approximately the same amount of capital investment but that credit use was 50 times larger on the units which had switched to crop farming [40, p. 82]. His study suggests that among this particular group of farms, large doses of credit played a leading role in the change from livestock to crop farming. In addition, his data indicate rather serious credit rationing problems. A number of small operators in southern Brazil are blocked from using available technologies such as fertilizer, which are highly productive at the margin, because most institutional credit is absorbed by large operators.

An evaluation of a supervised credit program in Colombia further suggests that a number of small farmers can profitably absorb more credit.[8] This program was begun in 1963 and has extended loans of up to $2,000 per farm in medium-term credit to farmers with modest land holdings [1]. These loans were a substantial increase over the $200 maximum which farmers had previously been able to borrow. Preliminary results of the evaluation indicate that substantial technological change is occurring on many of the participating farms. Borrowers have shifted to more intensive use of their resources; the value of purchased inputs has gone up sharply; much more labor is being used on the farms; and livestock inventories and net worth have grown substantially.

Several recent studies in India also strongly suggest that credit requirements dramatically increase when new technology is used [37, 47]. Additional fertilizer purchases, changes in irrigation systems, and more employed labor associated with use of new seed varieties may require a two- to four-fold increase in cash costs.

While data are inconclusive with regard to widespread agricultural credit shortage in Latin America, these studies suggest that credit bottlenecks may be occurring where the modernization process is most intense and especially among small farmers.

Concessional Interest Rates

Implications for farmers

As already suggested, alleged high interest rates in the informal credit market have been cited as a justification for concessional rates in the formal system. An additional defense for low rates has been that they provide the special inducement necessary to convince farmers to adopt productive inputs. But do farmers need to be bribed to do something that is supposedly profitable? A rather large amount of recent research has shown that farmers profitably allocate the resources at their disposal, including credit.[9] The recent rapid adoption of new cereal varieties in Asia also strongly suggests that farmers in LDC's will adopt very rapidly new technology if it is profitable [9]. A low-interest-rate bribe may simply induce farmers to make expenditures that would not be practical at rates charged for nonagricultural purposes.

Low interest rates for farmers have also been justified as an income transfer mechanism. That is, farmers are given a break on credit because they are presumed poor; or farmers are given concessional interest rates to partially offset national pricing or fiscal policy that adversely affects farm income.

Most of the institutional credit in Latin America is currently lent to relatively large landowners who often have other occupations. Since the income subsidy is tied to credit access, few of the benefits from concessional interest rates are filtering down to the rural poor. It is also an unanswered question as to how much of this fungible credit is leaking out of the agricultural sector through multiple occupational structures. Aside from the political and administrative advantages associated with the "invisible income transfers" through concessional interest rates, the practice has little in its favor. Direct cash payments, development of new technology, subsidizing the price of specific inputs, or adjusting pricing or taxing policies would seem to be a more efficient means of easing farm income problems.

[8] Don Bostwick, James Schwinden, and personnel from the Instituto Colombiano de la Reforma Agraria (INCORA) began this evaluation in 1970. A sample of some 600 borrowers from a total of about 35 thousand was included in the analysis. The credit program is administered by INCORA and partially funded by AID.

[9] No single review article draws together this research. Those wanting additional information on this point might review the discussion stirred by Schultz's book [44].

Implication for credit agencies

Low nominal interest rates combined with high rates of inflation erode the real value of credit portfolios. For example, if the rate of inflation in a country is averaging 25 percent per year and farmers are charged a nominal interest rate of 10 percent, a negative real rate of interest of 15 percent per year is implied. Under these conditions and without principal replacement, the real value of a credit portfolio is reduced to half its original value in a little over four years.[10] As suggested earlier, the high rates of inflation in Argentina, Brazil, Chile, Colombia, Peru, and Uruguay have resulted in negative real rates of interest having been charged on a large part of institutional agricultural credit during the 1960's. In Brazil a subsidy of $100 to $200 million per year has moved through institutional lending agencies to agricultural credit borrowers via these negative interest rates. Given this, it is even more remarkable that most high-inflation countries, with the exception of Uruguay, have been able to increase substantially the real value of their credit portfolios. Because of the capital washout, a much larger amount of capital has been transferred into agricultural credit systems than is indicated in the Appendix by the difference between dollar values of credit in 1960 and 1967–1968.

This capital erosion has obvious adverse effects on lending agencies. It tends to decrease the real value of the loan portfolio and forces the agency to look to external assistance for funds to increase its real size of portfolio. Under conditions of positive real rates of interest, lending agencies can build their portfolios by generating some internal profits. Because of low-interest-rate policy throughout most of Latin America, internal profits have been negligible. In addition, abstracting from the capital erosion problem, interest rates are often too low to pay out-of-pocket expenses. This is especially true where intensive supervision is tied to credit and overhead costs may run as high as 10 to 25 percent of the loan portfolio per year [1, 2, 11, 15, 19, 24, 29, 32, 36, 43, 55, 61]. Since overhead costs cannot be covered under these conditions, administrators are not "under-the-gun" to watch closely other administrative costs. Flabby administration can result.

It could also be argued that by holding the interest rates down governments have kept the private banking system and the informal credit market from providing substantial amounts of credit to agriculture. Governments thus are forced to try to legislate, usually unsuccessfully, the granting of agricultural credit by private banks [52].

In summary, there appears to be no strong set of reasons for granting concessional rates of interest to agriculture in Latin America.

Rural Savings Capacity

Little attention has been paid in the literature to capital formation and savings capacity in agriculture. Nurkse, Lewis, Ranis and Fei et al. effectively directed developers' attention away from this issue by stressing the use of "surplus" rural labor to form capital in urban settings. Because rural people were often poor, it was widely held that savings capacity in agriculture was very low and that little capital formation was taking place. It has also been assumed that these rural residents have low marginal propensities to save [28, p. 289]. Several important conclusions followed from these assumptions: (1) Little investment takes place on farms in less developed countries; (2) most investment that does take place must be financed by credit provided from sources outside of agriculture; (3) mobilization of capital from the agricultural sector must be largely done on an involuntary basis; and (4) since little savings capacity exists, institutions and incentives to save are not necessary in rural areas. Under these assumptions it is not surprising that international lending agencies have not encouraged countries to mobilize rural savings by offering favorable rates of interest as well as institutional forms.

A review of data on time deposits in savings institutions in Latin America shows that voluntary savings are relatively insignificant when compared to figures on domestic credit claims on private sector [22, 27]. This is especially true in Brazil with a ratio of savings to credit of only .13 in 1968. Bolivia, Chile, Colombia, Costa Rica, Ecuador, Nicaragua, Panama, Paraguay, and Uruguay had ratios of less than .40. The 18-country totals for Latin America show a ratio of only .42 in 1967 or 1968. Only Mexico has roughly as much voluntary institutional savings as domestic credit, a pattern that is general in developed countries.

Monetary depreciation, coupled with fixed low interest rates on savings, has provided little incentive for people to institutionalize savings.

[10] This can be calculated by using $i=1-1/1-R$, and $V=1/(1+i)^n$, where R=negative interest rate, i=a conversion factor, n=number of years, and V=half value in year n.

In Colombia, for example, the Agricultural Bank, which handles about one-half of the country's savings, pays only a 4 percent rate of interest; i.e., a rather healthy negative real rate of interest during the 1960's.

Unfortunately, very little information is available on how responsive rural people in Latin America might be to increases in the rates of interest paid on savings. Recent experience in Korea, however, suggests that the supply of savings may be rather elastic with respect to interest rates. In the last part of 1965 Korea approximately doubled the rate of interest that could be paid on time deposits [8]. Since this interest rate reform, the amount of time and savings deposits has doubled each year and an eightfold increase in number of savings accounts has been experienced. Unfortunately, there is no information available on how much of this dramatic increase in savings came from the rural area. There is little reason to think, however, that rural people did not participate in this in a major way.

In the early 1950's Taiwan was also quite successful in mobilizing voluntary savings by raising interest rates [10, 23]. Less well-documented cases of recent substantial increases in institutional savings resulting from interest incentives have also occurred in Indonesia and Turkey.

It may be that if rural people in Latin America had adequate economic incentives and access to a savings institution, substantial amounts of local capital could be mobilized to significantly complement external funds for credit, especially where income is increasing. Currently, rural people must hold savings in land investments or in livestock. The growth in credit unions during the past five years in Latin America shows that some additional capital can be mobilized if institutional forms are simply available [20]. Between 1963 and 1968, funds in credit unions in Latin America increased from less than 8 million dollars worth to about 57 million dollars [14, 25]. Approximately 30 to 40 percent of this has been raised in rural areas.

Present policy in Latin America results in large subsidies to credit users and yet almost completely discourages institutional savings. Does a significant amount of potential savings exist in rural areas of Latin America? Evidence from studies in Bolivia, Brazil, and Colombia suggests that rural savings capacity does exist [16, 18, 46, 60]. Could mobilization of these savings, especially in areas where rapid technological change is occurring—southern Brazil, Central Venezuela, and the Cauca Valley of Colombia, for example—provide a substantial portion of the agricultural credit needs? The possibilities look favorable enough to warrant focusing some policy attention on this area.

Conclusion

During the 1960's agricultural credit in Latin America was sharply increased. While still larger amounts will be needed during the 1970's and 1980's to facilitate further development, I would argue that policy priority ought now to be shifted away from simply increasing amounts. Emphasis should rather be placed on creating firm financial and economic foundations for rural credit systems.

In brief, I would suggest the following three issues for emphasis:

(1) Where interest rates on agricultural credit do not reflect opportunity costs of capital, high priority should be given to raising rates.[11] Market forces should have more sway in the allocation of these funds. Higher rates would likely enable small farmers to get and use more credit as large operators back away from credit with higher costs. Increased rates would also allow credit institutions to protect the real value of their loan portfolios and make them less dependent on external funding. More realistic interest rates would also encourage the growth in nongovernmental credit. Private banks, merchants, and other informal sources of credit would find it more profitable to participate in this activity.

(2) Far too little of the agricultural loan portfolio in Latin America is currently supplied by rural savings. An important increase in savings capacity is resulting from the expansion in rural income streams in a number of areas in Latin America. I feel that higher interest rates on institutional savings could help mobilize a significant part of this savings potential and that these voluntary savings could provide a major portion of future rural credit needs.

(3) More realistic prices on agricultural credit would bring into sharper focus the major constraints that are slowing agricultural development. Credit policies in a number of countries are currently obscuring these constraints. It is difficult, for example, to tell if input or product prices are seriously out of line. The economics of new technology, land tenure restraints, the

[11] Value linkage or principal readjustment should be explored in cases of very high rates of inflation [36].

importance of marketing and transportation costs, and the role of educational inputs are masked in many cases by current credit policy.

In a number of Latin American countries higher prices on agrucultural credit and rural savings will entail major changes in farm pricing policy, fiscal programs, and monetary policy. In order to encourage general movement in this direction, aid agencies will need to face Latin American countries with a united front. One agency's loan program that requires higher interest rates to be paid by farmers will not float in a sea of heavily subsidized credit.[13]

In order to convince countries to alter current policies, aid agencies must be well briefed on what their credit programs are achieving. Unfortunately, aside from a couple of cases of evaluation by AID and a few brief visits by IDB and IBRD officials, the economic results of the aid agencies' "billion dollar agricultural credit program" during the 1960's has been undisturbed by systematic research.

Appendix. Agricultural credit, rates of change, ratios to total credit, and gross domestic product from agriculture for 18 Latin American countries, 1960 to 1968

Country and year	Institutional agricultural credit year-end balances[a]			
	Agricultural credit[b]	Average annual rate of growth	Ratio to total credit[c]	Ratio to GDP from agriculture[d]
	(1)	(2)	(3)	(4)
	million dollars	*percent*		
18-country totals				
1960	2,439		.22	.23
1967 or 1968	4,730	12	.31	.36
Argentina				
1960	393		.17	.19
1968	555	2	.20	.28
Bolivia				
1960	2		.25	.02
1968	15	81	.47	.13
Brazil				
1960	606		.17	.18
1968	1,417	17	.33	.34
Chile[e]				
1960	127		.31	.57*
1968	213	7	.35	.77*
Colombia				
1960	231		.36	.19
1968	386**	8	.35	.26
Costa Rica				
1960	68		.60	.62
1968	104	7	.73	.67
Dominican Republic				
1960	21		.20	.10
1968	57	21	.33	.23
Ecuador				
1960	20***		.13	.07
1968	48***	18	.21	.13
El Salvador				
1960	40		.29	.22
1968	44**	1	.23	.19
Guatemala				
1960	39**		.41	.12
1968	52	4	.24	.13
Honduras				
1960	7		.20	.04
1968	31	44	.41	.16
Mexico				
1960	472		.41	.39
1968	1,065	16	.57	.68
Nicaragua				
1960	32		.62	.28
1968	85	21	.60	.53
Panama				
1960	6		.06	.06
1967	23	40	.10	.15
Paraguay				
1960	10		.36	.08
1968	33	29	.40	.22
Peru				
1960	116		.34	.22
1967	160	5	.36	.25
Uruguay				
1960	59		.14	.27
1967	18	−10	.06	.07
Venezuela				
1960	190		.16	.38
1968	448	17	.21	.50

[13] The difficulties recently experienced by the World Bank in Brazil on a livestock loan which was value-linked is a case in point.

* Net domestic product figures are used here rather thai gross domestic product.

** Includes some data estimated by the author.

*** Data is for new loans made during the year, rathe than year-end balances.

[a] Figures on agricultural credit represent institutiona lending and were taken mostly from annual or monthl reports of each country's central bank. In several cases annual reports of individual banks were used, and in one o two cases, unpublished Agency for International Develop ment reports were used.

[b] Local currency values in each case, except that som data for Mexico (see footnote[d]) and Chile (see footnote[e] were adjusted by the yearly consumer price index figures with base in 1963, published by the International Monetar Fund [22]. The 1963 exchange rate of local currency fo dollars was then used to convert to an "adjusted dolla value." The figures in the table, with the exceptions noted therefore show the 1963 purchasing power of local currenc in credit funds expressed in dollars.

[c] Agricultural credit (col. 1) divided by the correspond ing domestic-credit-claims-on-private-sector figure, take from International Monetary Fund [22]. The adjustment explained in footnote [b] were also made in the domesti credit claims on private sector figures.

(*Appendix footnotes con't. on next page*)

[d] Agricultural credit (col. 1) divided by the corresponding gross domestic product from agriculture for 1967, taken from United Nations [56]. For Brazil, 1968 GDP figures were used; for Bolivia, only 1966 figures were available. The adjustments explained in footnote [b] were also made in the gross domestic product from agriculture figures, except for Mexico. Mexican data were expressed in 1950 market prices and converted to dollars using the 1950 exchange rate of 11.57 pesos per dollar.

[e] Local currency values in Chile were adjusted by a yearly price index with base in 1965. The 1965 exchange rate of escudos was then used to convert each year to an adjusted dollar value. The figures for Chile therefore show 1965 purchasing power of escudos expressed in dollars.

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A Welfare Analysis of the Voluntary Corn Diversion Program, 1961 to 1966*

LEROY J. HUSHAK

The welfare effects of the corn diversion program are analyzed. A three-sector (corn, other crops, and the rest of the economy) supply-demand model is developed which incorporates substitution in production and consumption between corn and other crops. Using observed data as the restricted market equilibrium and parameters derived from previous research, free market equilibrium is estimated. The net welfare costs and income transfers are computed from the two equilibrium points. In general, the net welfare costs are small and the income transfers are substantial. However, the model is quite sensitive to the parameter values.

NUMEROUS STUDIES have been made of the impacts of United States agricultural policy, but two areas of weakness stand out. First, relatively few studies have been made of policies regulating the major crops for which significant substitution exists in both production and consumption, compared with analysis of the impacts of policy in the aggregate or on crops whose production is limited geographically and for which substitution is not significant. This study singles out corn and develops a welfare analysis of the voluntary corn diversion program during the 1961 to 1966 period. Second, an analytical framework is needed which allows the consideration of substitution among crops and the simultaneous analysis of several individual crop policies. A step is taken toward filling this need by expanding Wallace's input control model [14, p. 585] from two to three sectors, i.e., from crops and the rest of the economy to corn, other crops, and the rest of the economy. The model takes account of the effect of the corn program on both the corn market and the other crop market, in which other crops are assumed to be free of regulation and the rest of the economy is assumed to be unchanged.[1]

The voluntary corn diversion program began in 1961 under the feed grain program [11]. Background data on corn for grain during this period are presented in Table 1. The program imposes two restrictions on the market which are of concern. The first restriction is the support price, the price fixed by the government at which it buys or sells corn.[2] The government buys or sells enough corn to maintain the price.

The second restriction is on land in the form of direct payments to producers for taking land out of corn production. To receive direct payments, a producer must take a minimum of 20 percent of his average corn acreage before the program (corn base) out of corn production. He may retire and receive payments for 40 percent or more of his corn base, depending on expected production for the year. The land must be kept under a cover crop or summer fallow, and no crop may be harvested from it.[3]

The payments have taken three forms. In 1961 and 1962 payments were equal to about 50 percent of average yield[4] per acre times the support price for each acre removed from production. From 1963 to 1965 a subsidy of 15 to 20 cents per bushel on actual production was paid, in addition to a direct land payment of 20 percent of average yield per acre times the support price per acre removed. Beginning

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[1] The expansion of the Wallace model to an unlimited number of sectors is conceptually straightforward. The model of this paper is limited because the required parameter estimates expand rapidly with additional sectors, and it is not clear that the effects of a particular policy can be isolated in an expanded model. This lack of consideration of restrictive policies on other crops and the additional assumptions below make the model somewhat naive; but it is not clear that a more detailed model will result in better estimates, given our knowledge about the parameters of this or a more detailed model.

[2] While the price at which the government sells corn is greater than the price at which it buys corn at any point in time, no attempt is made to take this difference into account. To the extent that this difference is based on storage and transportation costs, which are excluded because the model is analyzed at the point of production, the omission will not cause any significant bias.

[3] While the Secretary of Agriculture has the option of allowing certain crops to be grown on retired land, the option was not used during the 1961–1966 period.

[4] Average yield is an average of yields from 1959 to the last year of production.

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Table 1. Data on corn for grain, United States, 1961–1966

	Support price	Market price	Output	Yield	Harvested acres	Government Stocks October 1
	dollars per	*bushel*	*million bushels*	*bushel per acre*	*million*	*million bushels*
1960		1.00				
1961	1.20	1.10	3,626	62.0	58.4	1,371
1962	1.20	1.12	3,637	64.2	56.6	867
1963	1.07[a]	1.11	4,092	67.6	60.5	803
1964	1.10[a]	1.17	3,584	62.6	57.3	828
1965	1.05[a]	1.16	4,084	73.8	55.3	540
1966	1.00[a]	1.24	4,103	72.1	56.9	249
1967						139
Average	1.10	1.11[b]	3,854	67.0	57.5	

[a] Does not include direct subsidy payments of 18 cents per bushel in 1963, 15 cents in 1964, 20 cents in 1965, and 30 cents in 1966.
[b] Average for 1960 to 1965.
Source: [10, year 1967].

in 1966 a subsidy of 30 cents per bushel was paid, based on average yield projected to the current year times the smaller of acreage planted or 50 percent of the corn base, with no direct payment for the first 20 percent of land removed. If additional land was retired, it was paid for directly under all versions of the program.

Direct payments for land and subsidy payments provide an alternative use or rent for land which producers will take if the rent to the land retired is greater than the rent would be if they did not participate in the program.[5] The government develops an estimate of the amount of land needed to produce the desired quantity of corn each year and sets a payment structure that will induce producers to divert enough land to reach that amount, fixing the quantity of land used for corn.

With the above as background, the next section develops and illustrates the free and restricted market models, after which the welfare analysis is developed. A third section provides estimates of free market equilibrium and the results of the welfare analysis. Finally, estimates are developed of the costs of administering the program and of storing stocks of corn, costs not included in the model. The analysis is limited to short-run (1–2 year) to medium-run (3–5 year) adjustment periods.

[5] The question of who receives this rent is discussed more fully later. A second effect of these payments is that producers, given participation, have a long-run incentive to increase yield to increase payments. The model assumes a yield equating price and marginal cost. Direct payments based on yield may cause the marginal revenue of additional yield to exceed the price of corn because of higher future payments, if the program is expected to continue for several years. This second effect is not considered.

Supply-Demand Model

The objective of this section is to specify the functional relationships of the free and restricted markets from which the welfare effects of the corn program can be computed. This involves two supply-demand models, a free and a restricted model, which can be directly compared. Each model explicitly consists of two sectors—corn and all other agricultural crops—and two factors of production—a fixed factor, land,[6] and a variable factor comprised of all other factors of production. The rest of the economy is not considered explicitly because it is assumed unchanged. Further limiting assumptions are: profit-maximizing firms, competition in the product and factor markets, the existence of a restricted market equilibrium in these markets, a constant level of technology, and unchanged population. The models are static; time enters only in the sense of the period required to move from the restricted to the free market equilibrium. The income effect of the program is not included.

The free market model (sector 1 is corn and sector 2 is other crops) is[7]

$$(1) \qquad X_1^d = B_1 P_1^{\eta_1} P_2^{\eta_{12}}$$

$$(2) \qquad X_1^s = C_1 P_1^{\epsilon_1} P_2^{\epsilon_{12}}$$

$$(3) \qquad X_1^s = X_1^d$$

$$(4) \qquad X_2^d = B_2 P_2^{\eta_2} P_1^{\eta_{21}}$$

$$(5) \qquad X_2^s = C_2 P_2^{\epsilon_2} P_1^{\epsilon_{21}}$$

$$(6) \qquad X_2^s = X_2^d$$

where

X_i^d = quantity consumed ($i = 1,2$, 1 = corn 2 = other crops)
X_i^s = quantity produced
P_i = price
η_i = own-price elasticity of demand
η_{ij} = cross-elasticity of demand for X_i with respect to P_j ($i \neq j, i,j, = 1,2$)
ϵ_i = own-price elasticity of supply
ϵ_{ij} = cross-elasticity of supply of X_i^s with respect to P_j ($i \neq j, i,j, = 1,2$)
B_i, C_i = constant terms.

Equations (1) and (4) are demand functions

[6] See footnote 5.

[7] The functional form of the model is constant elasticity (linear in the logarithms). On the supply side this form is implied by the generally superior performance of the Cobb-Douglas function over additive functions in the estimation of production functions. For simplicity the demand functions are assumed to have the same functional form.

for corn and other crops, respectively; (2) and (5), supply functions; (3) and (6), equilibrium conditions. Under the assumption that other factor prices are constant, other factors can be employed at optimum levels without cross-effects on production between sectors. This reduces the ϵ_{ij} to cross-elasticities of supply of land between sectors as the prices in the two sectors change, which is shown below.

To obtain the restricted model, the free market model is modified to incorporate the fixed price and fixed land provisions of the corn program. The support price is incorporated by replacing equation (3) with the parametric restriction

$$P_1 = \overline{P}_1, \tag{3a}$$

which becomes the equilibrium condition for corn. This is equivalent to a product demand of infinite elasticity to producers and a supply of infinite elasticity to consumers at the support price. Production no longer equals consumption unless the government is able to adjust production to consumption through the control of land. Otherwise the government buys or sells corn to make up the difference. Although the fixed price can be enforced only if the quantity demanded at $\overline{P}_1$ is less than production plus carryover stocks, the market situation for corn was well within this range from 1961 to 1966.

Fixed land is incorporated by a modification of equation (2). At any point

$$X_1^s = A_1 Y_1, \tag{7}$$

where A_1 is the quantity of land and Y_1 is yield per unit of land. In the neighborhood of X_1^s,

$$\epsilon_1 = \epsilon_{a1} + \epsilon_{y1}, \tag{8}$$

where ϵ_{a1} is the elasticity of supply of land and ϵ_{y1} is the yield elasticity, both with respect to the price of corn. With these two equations, the free market supply of corn can be interpreted as the product of a land supply and a yield function,

$$A_1 = C_{a1} P_1^{\epsilon_{a1}} P_2^{\epsilon_{12}} \tag{9}$$

and

$$Y_1 = C_{y1} P_1^{\epsilon_{y1}}, \tag{10}$$

where C_{a1} and C_{y1} are constants. The cross-elasticity term appears only in the land supply equation. Using (9) and (10), equation (2) in the free market model is written

$$X_1^s = C_{a1} C_{y1} P_1^{(\epsilon_{a1}+\epsilon_{y1})} P_2^{\epsilon_{12}}. \tag{2a}$$

Under the assumption that the yield function is not affected by the program,[8] specification of the restricted supply surface for corn reduces to replacing equation (9) by

$$A_1 = \overline{A}_1. \tag{9a}$$

Under this condition the restricted supply of corn is

$$X_{1r}^s = \overline{A}_1 C_{y1} P_1^{\epsilon_{y1}}. \tag{2b}$$

Figures 1 and 2 illustrate the model. The curves $D_k(P_{ij}$ or $\overline{P}_1)$ and $S_k(P_{ij}$ or $\overline{P}_1)$, i,j, $k=1,2$, trace the paths of the free market demand and supply functions at the corresponding prices in the other market. The curve S_{1r} represents the restricted supply of corn, equation (2b).[9]

In the analysis the actual production, consumption, and price of corn and other crops are assumed to represent the restricted equilibrium under the program. In Figure 1 production of corn is X_{12} and consumption is X_{11} at the support price $\overline{P}_1$.[10] In Figure 2 production equals consumption of other crops at X_{21} with the price of P_{21}.

In the free market model the equilibrium condition and land supply equation for corn change. The equilibrium condition requires that production equal consumption of corn. The land supply equation for corn is estimated under the assumption that producers have adjusted desired land use to the support price.[11] Under this assumption production would expand to X_{13} in Figure 1 at the price $\overline{P}_1$ if there were no restrictions on production. With the release of the support price this represents an excess supply of corn. As the price of corn falls the price of other crops falls with it until both sectors reach free market equilibrium at (X_{10}, P_{10}) for corn in Figure 1 and (X_{20}, P_{20}) for other crops in Figure 2.

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[8] It is generally held that retired land on average is of lower quality than producing land, but there is disagreement on the extent of this difference; e.g., see [6, p. 5]. The effect of such a difference is that, under the assumption that equation (10) is independent of land use, the model will overestimate the quantity and underestimate the price of corn in the free market.

[9] The remaining curves are explained at a later point.

[10] Consumption of corn exceeded production by an average of 227 million bushels from 1961 to 1966. However, the model is also valid when production exceeds consumption.

[11] The decline in the real price of corn over time suggests that the corn base is at least as great as desired free market land use at the support price.

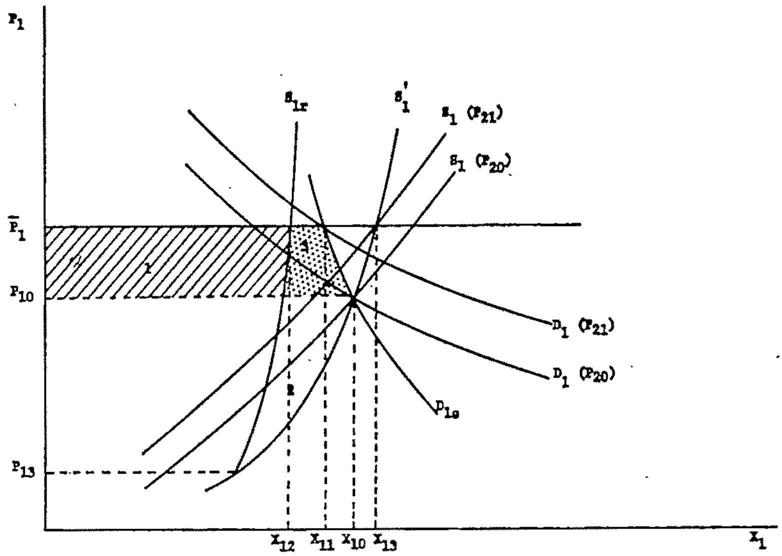

Figure 1. Illustration of sector 1, corn

Welfare Analysis

The objective of the welfare analysis is to estimate the change in the distribution of income and the loss of real income resulting from the restrictions imposed by the corn diversion program. Four welfare quantities are computed in the analysis: consumer costs, producer benefits, net welfare costs, and the change in variable factor income. Consumer costs is the loss of satisfaction to consumers because of the program.[12] Producer benefits is the increase in rent received by land, the restricted factor of production.[13] Under an ideal transfer program consumer costs would equal producer benefits. However, the program restricts the use of land and fixes the price level, which causes resources to be used less efficiently. Therefore, land receives only part of the loss to consumers. The

[12] Consumers include all persons who use agricultural crops and who pay taxes in support of the program.

[13] Land is the restricted variable of the program; strictly speaking, producers are landowners. However, operator labor in many cases is a fixed factor and, although not restricted by the program, may share in producer benefits. Vermeer [12, 13] has found that tenant farmers on crop share leases share in direct government payments in proportion to their share of the crop.

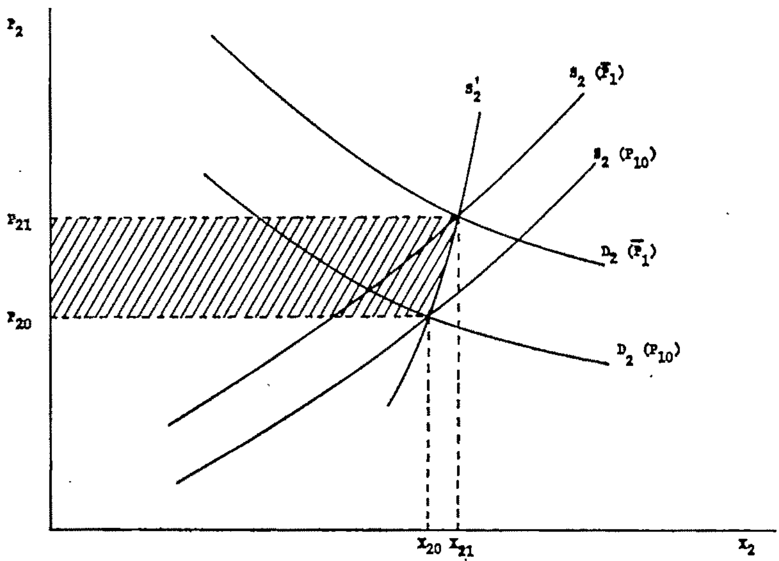

Figure 2. Illustration of sector 2, other crops

remainder is the net welfare cost, that amount lost through inefficient resource use. The change in variable factor income measures the total change in income received by variable factors of production.

The four welfare quantities include changes in consumer or producer surplus.[14] This requires the questionable but necessary assumption of constant marginal utility of income on the demand and supply functions.

The three-dimensional model is reduced mathematically to two dimensions in order to derive the welfare quantities. The curve S'_2 in Figure 2 is the trace in the X_2, P_2 plane of the locus of equilibrium points in sector 2 as P_1 varies. Equilibrium in sector 2 implies specific movements along the demand and supply function for corn. To obtain these movements the equations of sector 2, equations (4), (5), and (6), are solved to obtain P_2 as a function of P_1. This function is substituted for P_2 in the demand and supply functions for corn, equations (1) and (2), to obtain the two-dimensional functions represented by D_{1r} and S_1' in Figure 1. These two curves trace the path in the X_1, P_1 plane of their respective functions under the condition that sector 2 is in equilibrium.[15] The derivation of the welfare effects is based on these reduced functions. Although the quantities are defined for each sector, only the total quantities have direct relevance. It should be recalled that the implicit rest of the economy sector is the base on which the definitions rest.

In sector 1 consumer costs are the change in consumer surplus, plus direct government payments to producers which consumers pay as taxes, minus a pure transfer between consumers and the government because the government sells corn from stocks at a price other than the free market equilibrium price. The change in consumer surplus is the sum of areas 1 and 3 in Figure 1, i.e., the change in satisfaction due to a change in price. Direct government payments are the land and subsidy payments for land diversion, which averaged \$834 million during 1961 to 1966. The pure transfer, offsetting part of area 3 in Figure 1, is

$$T = (\overline{P}_1 - P_{10})(X_{11} - X_{12}). \tag{11}$$

Producer benefits from corn are the sum of the change in producer surplus and direct government payments. The change in producer surplus is area 1 minus area 2 in Figure 1. Area 1 is the part of the loss to consumers that producers receive through the change in the price of corn. Area 2 is the loss from inefficient resource use because of the restriction on land use. This area measures, not the loss from inefficient use of resources to produce corn, but the total loss to the economy from the inefficient use of resources because of restricting the use of land to produce corn.

Net welfare costs in sector 1 are consumer costs minus producer benefits, or the sum of areas 2 and 3 in Figure 1 minus equation (11), the pure transfer. The change in variable factor income in sector 1 is the change in gross income from corn minus the change in producer surplus.

In sector 2, under the assumption of free adjustment to restrictions on corn, net welfare costs are zero.[16] The total loss from inefficient resource use is measured in sector 1, area 2, in Figure 1. The change in consumer surplus that is not captured by producers is also measured in sector 1 because the demand function takes account of the change in the price of other crops, area 3 in Figure 1 minus equation (11).[17]

Since welfare costs are zero in sector 2, consumer costs equal producer benefirs, the shaded area in Figure 2. The change in variable factor income from other crops is the change in gross income minus producer benefits.

To obtain the total effects of the voluntary retirement program, the welfare quantities from both sectors are summed. Total consumer costs, producer benefits, and change in variable factor income are the sums of their respective components in sectors 1 and 2. Total net wel-

[14] See Mishan [5] for a more complete discussion of producer surplus. Producer surplus as used here corresponds to Mishan's economic rent, although operator labor receives part of the transfer in the periods considered here (see footnote 13). See Marshall [4, pp. 124–33] for the original development of consumer surplus, and Harberger [2] for a fuller treatment.

[15] The procedure was suggested by A. C. Harberger. It is developed more fully in Hushak [3]. In Figure 1, S_{1r} lies to the left of S_1' because land use is fixed on S_{1r} and is less than land use on S_1' above P_{12}.

[16] In the present case sector 2 adjusts by moving along its demand and supply functions as other crops are substituted for corn. However, even if diverted corn land were used for other crops and the supply function for other crops shifted outward, there would be no welfare costs in sector 2 because sector 2 is adjusting freely to the corn program. The reduction of the model to two dimensions, keeping sector 2 in equilibrium, has the effect of collapsing the net welfare cost of the program into sector 1.

[17] Technically, the part of area 3 to the left of X_{12} is due to inefficient resource use but is included with the change in consumer surplus for simplicity.

fare costs are equal to net welfare costs in sector 1 since they are zero in sector 2.

Results

The program is analyzed on the basis of its estimated effects on the market, not on the basis of its stated objectives. The data are assumed to represent the restricted equilibrium point under the voluntary program.[18] In sector 1 the support price, hereafter referred to as the average price under the program, is defined as the average price lagged one year received by producers for corn from 1961 to 1966.[19] Production is actual average output of corn for grain during the period. Restricted acreage is actual average acreage harvested for grain, from which yield can be derived. Consumption is defined as production plus average government stock disposal.[20]

In sector 2 the index of prices received by farmers for all crops (1910–14=100 using a July 1 to June 30 crop year) is adjusted to eliminate the price of corn to get an index of prices received for other crops,

$$I_2 = \frac{I - w_1 I_1}{w_2}, \tag{12}$$

where I, I_1, and I_2 are the index numbers of all crops, corn, and other crops, respectively, and w_1 and w_2 are the value shares of corn and other crops, $w_1+w_2=1$. The other crop price is an average of I_2 lagged one year. Production of other crops is an average of

$$X_2 = \frac{\text{value of all crops} - \text{value of corn}}{I_2}. \tag{13}$$

Estimates of the parameters and free market land use are presented in Table 2. The demand parameters are derived from previous research on the demand for agricultural products.[21] The supply parameters are estimates obtained from time series regressions of yield and land supply equations for corn and other crops. The yield and land supply equations for other crops are derived in the same way as they were for corn in equations (9) and (10). The short-run parameters in Table 2 are estimates from equations using price variables lagged one year. The medium-run parameters are estimates from equations using three-year weighted average lagged prices. The free market land use estimates are based on regressions for periods of unrestricted land use and an examination of the trend in land used for corn production. The lower and upper bounds represent limits that are likely to contain the true parameter values.[22]

The cross-elasticities are assumed to be proportionally related to own-price elasticities to reduce the number of parameter combinations. Under the assumption that the demand functions are homogeneous of degree zero in income and prices, the relation $\eta_{12}=-0.2\eta_1$ was derived at $\eta_1=-0.5$ and was assumed to hold for all values of η_1.

The Slutsky symmetry condition gives the relation

$$\eta_{21} = \frac{X_1 P_1}{X_2 P_2} \eta_{12}$$

Table 2. Parameter and land use estimates, 1961–1966

	Lower bound	Short run	Medium run	Upper bound
Corn				
Demand elasticity	−0.3	−0.5	−0.5	−0.7
Yield elasticity	0.01	0.1	0.1	0.2
Land elasticity	0.1	0.2	0.4	0.8
Land use (mil. A.)[a]	58.0	60.0	60.0	66.0
Other Crops				
Demand elasticity	−0.2	−0.4	−0.4	−0.7
Yield elasticity	0.01	0.1	0.1	0.2
Land elasticity	0.1	0.2	0.4	0.8

[a] Estimated free market land use for corn at the 1961 to 1966 average price of corn.

[18] The data are from [9, 10].

[19] The average price received is used rather than the government support price because it is the price actually achieved in the market by the program. The average price received is referred to as the average price under the program to prevent confusion of this price with the announced support price.

[20] This definition of consumption is equivalent to total disappearance of corn, i.e., domestic consumption, exports, and waste or loss.

[21] No attempt is made to cite a complete list of demand studies. The most frequently used study was Brandow [1].

[22] The analysis is restricted to shorter-run periods because of an almost complete lack of knowledge of the long-run supply parameters. As many as four values of each parameter were used to see how sensitive the model is to changes in parameter values. It is not possible to make a probability statement about the lower and upper bounds because of the way in which the parameter values were derived. The demand parameters were derived from a synthesis of the results of demand studies. High multicolinearity resulted in high standard errors for the coefficients of the supply equations. It was necessary to base the supply parameter estimates on the results of regressions using varying sets of predetermined variables. Generally, the estimates of elasticity coefficients were quite stable as the set of predetermined variables other than P_1 and P_2 were varied.

under the assumption that the term involving income elasticities is zero. On the supply side the relations $\epsilon_{12} = -0.7\ \epsilon_{a1}$ and $\epsilon_{21} = -0.125\ \epsilon_{a2}$, where ϵ_{a2} is derived in the same manner as ϵ_{a1}, were derived at the short- and medium-run estimates of ϵ_{a1} and ϵ_{a2} and were assumed to hold for all values of these parameters.

The model is solved and the welfare computations are made for all possible combinations of the parameter values in Table 2. Two sets of results are presented. The set in Table 3 is estimated under the assumption that the government does not dispose of stocks under free market conditions. The set in Table 4 is estimated under the assumption that the government disposes of stocks in the free market at the same rate that it actually disposed of them under the program in the 1961–1966 period. Stock disposal averaged 227 million bushels during this period.

In Table 3 the short- and medium-run estimates show that the price of corn increases about 2 percent to $1.13 from the $1.11 average price under the program, with a range of $0.91 to $1.26. The short- and medium-run estimates indicate corn production increases about 5 percent over restricted production of 3,852 million bushels, while the range is 2 to 14 percent.

The short- and medium-run estimates of the price of other crops show an increase of less than 1 cent per unit over the average price under the program of $2.50. The estimates range from $2.46 to $2.53. Production of other crops shows little change from production under the program of 6,730 million units, with maximum changes of less than 0.5 percent.

As stated above, only the totals of the welfare quantities are directly relevant. The components are presented in Table 3 to show the composition of each quantity. Total consumer costs range from $99 million to $1,959 million, with the short- and medium-run estimates around $740 million. The short- and medium-run estimates are 3.5 percent of the $21,382 million average value of all crops consumed, while the maximum is over 9 percent.

The short- and medium-run estimates of total producer benefits are about $720 million, with a range of $78 million to $1,746 million. The short- and medium-run estimates are about 3.5 percent of the $21,129 million average value of all crops produced,[23] while the maximum is over 8 percent.

Net welfare costs of the program are small with a maximum of $261 million, about 1 per-

[23] The values of corn produced and consumed differ because of stock disposal by the government.

Table 3. Estimates of free market equilibrium and associated welfare effects with no stock disposal in the free market, 1961–1966

	Program	Short run	Medium run	Minimum[a] elasticity and maximum A_1	Maximum[a] elasticity and minimum A_1	Absolute[b] minimum	Absolute[b] maximum
Corn							
Price (cents per bushel)	111.24	113.34	112.94	90.82	114.58	—	125.64
Output (million bushels)	3,852.00	4,041.75	4,048.92	4,330.09	3,996.98	3,910.02	4,376.84
Other Crops							
Price (cents per unit)	250.29	250.63	250.60	245.62	250.88	—	253.13
Output (millions per unit)	6,730.00	6,729.66	6,729.26	6,733.18	6,726.23	6,709.22	6,764.76
Welfare Quantities (million dollars)							
△Consumer surplus$_1$	—	−84.91	−68.60	857.69	134.45	−577.09	—
Stock disposal$_1$	—	4.70	3.86	−45.67	7.57	—	32.69
Direct government payments$_1$	—	834.30	834.30	834.30	834.30	—	—
Consumer costs$_1$	—	754.08	769.56	1,646.32	707.42	289.90	—
Consumer costs$_2$	—	−23.30	−21.69	313.08	−40.29	−190.71	—
Consumer costs	—	730.79	747.87	1,959.40	667.13	99.19	—
△Producer surplus$_1$	—	−103.45	−78.15	598.53	−131.48	−565.19	—
Producer benefits$_1$	—	730.85	756.15	1,432.83	702.82	269.11	—
Producer benefits	—	707.55	734.46	1,745.91	662.56	78.39	—
Net welfare costs	—	23.27	13.41	213.49	4.57	—	261.07
△ Variable factor income$_1$	—	−191.58	−208.70	−245.35	−162.35	−397.47	−63.10
△ Variable factor income$_2$	—	0.87	1.85	−7.88	9.46	−86.52	52.19
△ Variable factor income	—	−190.71	−206.84	−253.23	−152.89	−421.17	−47.59

[a] These two columns represent extreme parameter points. A_1 is land use for corn.
[b] These are extreme values, presented only when they lie outside the values in columns 2 to 5.

Table 4. Estimates of free market equilibrium and associated welfare effects with stock di posal in the free market, 1961–1966

	Program	Short run	Medium run	Minimum[a] elasticity and maximum A_1	Maximum[a] elasticity and minimum A_1	Absolute[b] minimum	Absolute[b] maximum
Corn							
Price (cents per bushel)	111.24	105.37	106.48	78.73	110.65	—	—
Output (million bushels)	3,852.00	3,957.32	3,936.92	4,266.21	3,866.79	3,860.69	4,345.01
Other Crops							
Price (cents per unit)	250.29	249.30	249.36	242.66	250.20	—	250.23
Output (millions per unit)	6,730.00	6,731.23	6,732.39	6,736.16	6,730.71	6,713.75	6,790.39
Welfare Quantities (million dollars)							
△ Consumer surplus$_1$	—	229.19	185.77	1,315.10	22.22	22.09	—
Direct government payments$_1$	—	834.30	834.30	834.30	834.30	—	—
Consumer costs$_1$	—	1,063.49	1,020.07	2,149.40	856.52	856.39	—
Consumer costs$_2$	—	65.69	61.77	513.93	6.24	4.17	—
Consumer costs	—	1,129.15	1,081.84	2,663.33	862.76	862.64	—
△ Producer surplus$_1$	—	215.00	179.75	1,118.73	22.09	21.97	—
Producer benefits$_1$	—	1,049.30	1,014.05	1,953.03	856.39	856.27	—
Producer benefits	—	1,115.00	1,075.81	2,466.96	862.64	862.51	—
Net welfare costs	—	14.18	6.03	196.40	0.12	0.06	246.27
△ Variable factor income$_1$	—	−99.31	−85.84	−191.64	−15.73	−316.20	−8.99
△ Variable factor income$_2$	—	−3.09	−5.96	−15.20	−1.05	−149.74	40.29
△ Variable factor income	—	−102.40	−91.80	−206.81	−16.78	−371.94	−8.65

[a] These two columns represent extreme parameter points. A_1 is land use for corn.
[b] These are extreme values, presented only when they lie outside the values in columns 2 to 5.

cent of the value of crops consumed. However, welfare costs do reach about 10 percent of consumer costs; i.e., as much as 10 percent of the income transferred from consumers to producers is lost through the program restrictions. The change in variable factor income is a decline of $48 million to $421 million, centering around $200 million. These quantities are relatively small because the elasticities of supply and demand are small, which implies that relatively large income transfers can be realized with small resource distortions.

The results in Table 4, estimated under the assumption of 227 million bushels of stock disposal per year in the free market, differ from those in Table 3 in expected directions. Free market outputs and prices of corn and of other crops are lower than in Table 3, while consumer costs and producer benefits are larger. No stock disposal adjustment is needed because stocks are outside the model; i.e., the demand for corn is net of stock disposal. Net welfare costs and the decline in variable factor income are lower because the relative resource distortion is less than in the previous case. This is a short-run only case because stock disposal will last no longer than government stocks, and government stocks of corn were nearly depleted by the end of the 1966 crop year.

Administration and Storage Costs

Administration costs of the Feed Grain Pr gram averaged about $34 million from 1961 t 1963 [7, p. 13]. The share of corn in this co is probably about $30 million. If administratio costs averaged $30 million over the 1961–196 period, all estimates of consumer costs and n welfare costs in Tables 3 and 4 are increase by this amount.

The incorporation of storage and handlir costs of government stocks into the model d pends on acceptable methods of disposal. also depends on the substitution between go ernment and private stocks. For simplicity i illustrating alternatives, it is assumed th private stocks do not depend on governmer stocks, although this dependence exists.

As of 1960 annual storage costs for cor averaged about 14 cents per bushel.[24] Valuin corn at $1.00 per bushel and assuming a 5 pe cent return on capital, there is an addition cost of 5 cents per bushel, or a total annu

[24] This estimate is derived from data on storage costs [8]. Commercial storage costs are 10 cents per bushel pl 8 cents for handling, shrinkage, and return on investmen or 18 cents per bushel. Costs in government-owned stora facilities are 5 cents per bushel plus 5 cents for handlin shrinkage, and return on investment. The arithmetic mea of these two estimates is 14 cents per bushel.

cost of 19 cents per bushel. On October 1, 1961, the Commodity Credit Corporation (CCC) owned 1,371 million bushels of corn. Had these stocks been stored for the entire period, the annual costs would have been $260 million. Under the voluntary program the CCC held an average of 780 million bushels during the period, resulting in storage costs of $148 million.

The estimates in Table 4 are not affected because the free market has the same level of stocks that existed under the program. In Table 3, if the CCC had destroyed its stocks with a free market as of October 1, 1961, consumer costs and net welfare costs would be increased by $148 million, the cost of storing the average quantity of stocks owned by CCC under the program during this period. On the other hand, if CCC had to store all the stocks in a free market, consumer costs and net welfare costs in Table 3 would be decreased by $112 million, the difference in cost between storing all the stocks and average stocks under the program during this period.

Summary and Conclusions

A supply-demand model is used for a welfare analysis of the voluntary corn diversion program. It is a two-sector model, which allows an analysis of the effects of the program on other crops under the assumption that other crop markets are free of restrictions.

This analysis shows that the major effect of the program was on the transfer of income from consumers to producers. The price of corn during this period was near free market levels, output was reduced sufficiently to dispose of government stocks accumulated during the 1950's, although at a cost to consumers of the order of $3.70 per bushel sold from stocks.

The resource distortions were small because of the relatively inelastic demand and supply functions. Net welfare costs reach a maximum of about 10 percent of the total income transfer but are probably closer to 3 percent.

The addition of administration and storage costs modifies these results, however. Administration costs are about 3 percent of producer benefits at the short- and medium-run estimates, which increases welfare costs from 3 to 6 percent of the income transfer. Storage costs of government stocks have a positive or negative effect, depending on alternatives. They modify the results from showing a net welfare gain from the program to welfare costs of over 50 percent of the additional income received by producers at the short- and medium-run estimates.

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A Model of Competitive Behavior in Food Industries*

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While conventional industrial organization theory has been used to explain behavior of the food distribution oligopoly, a more careful analysis shows its behavior tendencies to be basically different from the manufacturing oligopoly. The larger distribution firm tends toward price competition while the smaller tends toward nonprice competition. The interaction between manufacturing and distribution oligopolies in the food industry provides a unique balance between progressiveness and economy which is not available in industries where the distribution oligopoly has not developed. This different consequence of large firms brings up some basic questions about antitrust objectives and philosophy.

There is a need for a better map to identify main directions and milestones of competitive activity in food industries. Typically, economists apply general industrial organization theory and hope for the best. That is not sufficient. Industrial organization theory is designed for a distributive channel dominated by a manufacturer. No model has been developed concerning behavior within a channel dominated by a distributor. The "big business" distributor occurred only infrequently outside food industries until recently. The economic characteristics of the large distributor have not been extensively studied.

In addition, general industrial organization theory as typically applied has had little success in accommodating the usual conflict between efficiency-oriented performance norms and performance dimensions having to do with progress and qualitative change. This conflict has prevailed because no one was willing or able to determine how much emphasis should be given to efficiency as against progress. As a result, Bain and others list both progress and efficiency norms as aspects of performance. While that may be sensible, it is impossible to apply to any particular firm. Organization imperatives for physical efficiency are different from those of product progress. This model accommodates this conflict by presenting a manufacturing-distribution channel specialized toward economy and process innovation separate from but competing with another emphasizing product progress. Here consumers, by allocating their purchases between the two channels, can select their preferred balance of emphasis.

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The food industries make a good laboratory for studying industrial organization. As well as being the oldest and biggest industrial complex, it is clearly the most structurally mature. Its size allows a degree of specialization among structural configurations not well developed in most other industries. Its size and proximity to consumer interests have stimulated constant analysis which creates a massive body of data.

The National Commission on Food Marketing assembled a useful stock of data on this industry. We have more data than understanding. This situation offers an opportunity to revisit some of the primary questions concerning industrial organization. This paper will undertake the task of extending and modifying standard conceptual framework in light of observations available.[1]

The conceptual framework we use is an outgrowth of Bain's work. Major extensions or changes are the following:

(1) A model of bilateral interaction (large manufacturer vs. a large distributor) is developed.
(2) Functional specialization among manufacturing and retailing substructures[2] is recognized.

Other changes will be noted: Extensive use is made of multidimensional performance characteristics, and the model is not limited to single-product markets; multiproduct manufacturers and distributors and the addition and dropping of products are comfortably accommodated.

[1] These data are not presented as a test of the hypothesized model. In fact, the model was developed from these observations.

[2] "Substructure" refers to a group of firms within an industry structure that portray similar market behavior. Any sharp boundary between substructures tends to be blurred by exceptions. Traditional discussion of "oligoply core" and "competitive fringe" is an example of substructure recognition.

The Model

This model is specified schematically rather than quantitatively. It depends upon the identification of substructures within the food distribution system. Behavior patterns ascribed result primarily from the tendency toward specialization by the various substructures. The structural elements of this model include:

(1) A food manufacturing oligopoly core.
(2) A large fringe[3] of small- and medium-size food manufacturing firms.
(3) A food distribution oligopoly core (large food chains).
(4) A large fringe of small-and medium-size food retailing firms.

Alignment of these substructures is of particular interest. Oligopoly core manufactueres tend to work most directly with fringe distributors. This combination constitutes a channel that emphasizes innovation and progress as regards the character of the product and services. It is on this basis that products within this channel are differentiated. Oligopoly core distributors tend to emphasize private label programs; hence, they are best served by the fringe processors. This substructure combination is a separate channel organized to emphasize physical efficiency and price competition. The drive for physical efficiency directs innovative activity within this channel toward process development as opposed to product development. Products within this channel tend to be differentiated on a price basis.[4]

Substructure specialization

The primary direction of competitive behavior results from functional specialization within each substructure. The character of this behavior pattern emerges as the organizational features of the various types of firms are identified.

Core manufacturers.—These food manufacturers are large firms, usually diversified into many products. Brands are important to them. A major part of their competitive strategy revolves around improving brand meaning and impact. Product and market research certainly fit into this category. Advertising, promotion, and new product introduction skills also pertain to brand selling. These functions are expensive and probably have significant scale economies. Therefore, larger firms have a competitive advantage in the introduction and marketing of new products.[5]

Core distributors.—The primary competitive advantage of core distributors is their preretailing operations. All core distributors have warehouses, manufacturing plants, quality control laboratories, and computer-controlled logistic systems. Please note that the preretailing advantages of the core distributor structure pertain to matters of cost and efficiency, not product quality. In pressing the economy alternative, larger distributors tend toward lockstep merchandising plans favoring high volume standard quality products. These private-label products of core retailers are some of the industries' most extensively differentiated products. However, they convey a different meaning from most differentiated products. Private-label products represent standard quality at minimum cost. Their appeal is economy.

Fringe manufacturers.—These many small- and medium-size food processors have little or no marketing capability. If they have a brand, it means little to consumers. Brand development costs are exorbitant for their small volume. They find private-label business very compatible with their physical structure and capabilities. Private-label programs enable them to specialize in the physical functions of food processing—their primary competitive advantage.

Fringe distributors.—Small- and medium-size distributors do not have the preretailing cap-

[3] The use of the term "fringe" needs clarification. Previous studies have rarely developed any precise definition for this term, but it has come to imply a small number of small firms contributing a small share of market volume. In this study the substructure boundaries are drawn on the basis of specialized behavior patterns. It turns out that the "small firm substructure," here called the fringe, has a large number of firms and contributes the majority of industry output.

[4] While the basis for differentiation differs, there are of course instances within both channels where differentiation is more illusionary than real.

[5] We do not mean to imply that new products and technology are not developed by fringe manufacturers. Several studies have addressed the relation between innovation and firm size [1, 8, 18, 19]. Measures of innovation include R and D expenditures, output of patented inventions, and the adoption rate of new technology. The frequent conclusion is that no particular advantage seems to rest with large firms. This conclusion says little about scale economies in a market for consumer goods under conditions of general affluence (literally thousands of product alternatives). These conditions require significant introduction and promotion activity. Here large firms clearly have an economic advantage.

abilities of the big chains. Their advantages involve greater merchandising flexibility. Smaller retailers use this flexibility to adapt their stores to the particular needs of communities they serve. The wider variety of more progressive products from core manufacturers fulfills their product and service needs. In competing with the standard offerings of large chains, fringe distributors have become more innovative in store design as well as merchandise variety. In this way, their competitive advantage is compatible with the competitive emphasis of core manufacturers.

This sharp distinction between substructures and channels may seem overdrawn. From whatever vantage point, any careful observer of the large and varied food industries will find several exceptions. Yet, it is useful, in understanding this sector's performance, to know the general and significant rules of its behavior.

Competitive interaction

For most products, core manufacturers and core distributors avoid direct confrontations. While these two major foci of power seek consumer attention and patronage, they do it in different ways. The manufacturing oligopoly stresses product development and is clearly more adept at this function than the distribution oligopoly. The latter is able to dominate the terms of trade for standard products and merchandise them to the public with an economy emphasis through extensive private-label programs. This situation channels the energy of the large aggressive firms toward presenting and accentuating consumer alternatives rather than into a socially expensive and unproductive fight.

Empirical Analysis[6]

The basis for behavior patterns asserted by the model is now identified. In presenting the model as a framework of general tendencies concerning competitive behavior, it is desirable to know the consistency between data and the model and the extent of exceptions.

Food manufacturing

Structure.—There are approximately 30,000 food manufacturing firms in the United States. Within this group the 100 largest firms, which include the largest members of most food processing industries, are defined as the oligopoly core. Each firm within this substructure has assets in excess of $50 million. The fringe substructure consists of the remaining several thousand food processing firms. Of the major four-digit food industries producing primarily consumer products, only cereal preparations, cocoa products, chewing gum, and cane and beet sugar refining do not have a substantial manufacturing fringe. Significantly, private-label sales have been small or nonexistent in these industries. The existence of a viable fringe substructure would likely increase the actual or potential supply of private-label products and thus improve performance in the economy dimension.

Core firms are growing at a slightly faster pace than the food industry as a whole. The 100 largest firms accounted for 42 percent of total food industry value added in 1954 and for 46 percent in 1963 [15, p. 21]. The increased concentration of value added is due more to diversified rather than horizontal growth of large food manufacturers. The top four positions of five-digit food product classes held by the 100 largest food manufacturers increased from 63 percent in 1954 to 70 percent in 1963. In addition, analyses by Michael Gort [6, p. 68] and the Food Commission [15, pp. 43–58] indicate that within this large firm group, diversification is positively correlated with size of firm. This is consistent with the functional orientation of large firms.

Mergers have played an important role in this diversification process. Between 1960 and 1965 the 50 largest food manufacturers completed 294 food and nonfood acquisitions. Of these, 64.9 percent were conglomerate mergers; 18.4 percent were horizontal; and 16.7 percent were vertical [15, p. 111]. From 1950 to 1965 the 50 largest firms increased their assets by $8,203.4 million. Measured in 1965 dollars, $2,279.7 million, or 27.8 percent of this growth, resulted directly from acquisitions. Over 70 percent of asset growth resulted from internal expansion.[7]

Rather than accumulation of assets, mergers have primarily facilitated the expansion of large firms into additional industries. Table 1 shows that between 1950 and 1966, 25 leading food manufacturers entered a new type of food processing business 108 times. Ninety-six of these instances, or almost 90 percent, resulted

[6] Taken from [7] and [17] except where otherwise indicated.

[7] Computed from [15, Appendix Table C-2, p. 263, and Table 7, p. 119]. See [7, p. 64].

Table 1. Industrial expansion by merger and internal growth of 25 leading grocery product manufacturers, 1950–1966

Firm	Number of food processing businesses				
	In 1950	Dropped after 1950	Added after 1950		In 1966
			Mergers	Internal expansion	
Consolidated Foods	4	2	11	0	13
Beatrice Foods	7	1	8	1	15
PepsiCo	3	0	8	0	11
American Tobacco	1	0	6	0	7
Borden	11	1	5	3	18
General Mills	3	0	5	0	8
Corn Products	3	0	5	1	9
National Biscuit	6	0	5	0	11
Pet Milk	5	0	5	0	10
Continental Baking	2	0	4	0	6
H. J. Heinz	4	0	4	0	8
Proctor & Gamble	2	0	4	0	6
R. J. Reynolds	1	0	4	0	5
Coca-Cola	2	0	3	0	5
Hunt Foods	2	1	3	0	4
Pillsbury	2	1	2	2	5
Campbell Soup	2	0	2	1	5
General Foods	13	2	2	1	14
Carnation	6	0	2	0	8
Ralston Purina	3	0	2	0	5
Standard Brands	4	0	2	0	6
Unilever	6	0	1	2	9
National Dairy	9	0	1	1	11
Beech-Nut	3	0	1	0	4
Foremost	5	0	1	0	6
Total	109	8	96	12	209

Source: [15, p. 125].

from mergers. Consolidated Foods was the most merger-prone firm with 11 acquisitions, followed by Beatrice Foods and PepsiCo.

Market behavior.—Data generally support the concept of functional specialization within each substructure. Most core manufacturers who traditionally received a large percent of sales from standardized commodities have over the past years drastically cutrailed these activities and shifted toward marketing specialized consumer products.[8] Accompanying this transition has been an increase in the number of products sold per manufacturer. For 88 large food manufacturers, *Progressive Grocer* calculated an average of 111 products sold per manufacturer in 1964, compared with an average of 73 items in 1959.

Several costs are associated with marketing strategies emphasizing new products. One cost factor is a high rate of product turnover. Since 1959, each of the 88 large firms mentioned above introduced an average of 45 new items and dropped an average of 7 items. As an example, annual reports indicate that from 1955 to 1963 Quaker Oats introduced 37 products while withdrawing 17 products from distribution.

Another cost factor is extensive product and market research necessary to support product innovation activities. In 1954, eighteen large food manufacturers each averaged $1.4 million, or 0.5 percent of sales, for product and market research. By 1964 these same firms averaged $3.3 million, or 0.9 percent of sales, for this activity. Most new products undergo test-marketing before they are introduced. For 72 new products studied this activity cost an average of $248,000 per product [13, pp. 22, 31, and 35]. Additional expenses associated with product development are the time and risk factors. For 127 distinct new products studied, an average of 27 months was required to achieve full distribution from the time formal research began. The study further showed that of 124 new products introduced by 16 core manufacturers, only 61 percent reached full distribution [13, p. 39].

Advertising and promotion are intricate facets of brand selling. It is well-known that advertising expenditures are highly concentrated among the largest firms. Estimates of the share of food industry advertising expenditures accounted for by the 50 largest food manufacturers range up to 80 percent or more [15, p. 65). In 1966 food manufacturers with assets of $50 million and over averaged 3.5 percent of sales for advertising; firms with assets below $50 million spent an average of 0.9 percent [20, p. 21].

The movement of advertising expenditures over time indicates that functional specialization among food manufacturing substructures has increased. Table 2 shows that from 1954 to 1965 advertising as a percent of sales has remained almost constant for fringe manufactures (assets below $50 million), indicating their continued emphasis on physical functions of production rather than any attempts to compete with large firms in the area of brand development.

Fringe manufacturers instead rely heavily on the private label programs of wholesalers and retailers for market outlets. Data collected by the National Commission on Food Marketing

[8] In 1949 bread contributed 71 percent of total sales for Contineta1 Baking compared to 51 percent in 1966, while specialty foods increased from 1 percent to 21 percent of total sales. In 1966, three of the four largest milling companies received less than one-third of sales from flour and mill feed; prior to 1950 all flour milling companies had received 80 percent or more of sales from this source. From 1954 to 1966 fluid milk and butter dropped from 53 percent of Beatrice Foods Company's total sales of 32 percent, while specialty food products increased from 19 percent to 38 percent of total sales.

Table 2. Advertising expenditures of food manufacturing corporations as a percent of sales, by asset

Asset size class	Advertising as a percent of sales					
	1954	1958	1959	1960	1961	1965
All food manufacturing corporations	1.8	1.9	2.1	2.2	2.1	2.3
Fringe manufacturers						
0–$ 99,999	0.9	0.9	0.7	0.8	0.8	0.9
$ 100,000– 999,999	1.1	1.0	1.3	1.1	0.9	0.9
1,000,000– 49,999,999	1.7	1.6	1.8	1.8	1.7	1.9
Core manufacturers						
$ 50,000,000–$99,999,999	2.5	2.6	2.5	2.6	2.9	3.2
100,000,000 and over	2.1	2.7	2.9	3.3	3.2	3.3

Source: [21].

indicate that the output of small fruit and vegetable processors averaged 70 percent private label [11, p. 191]. Less than 4 percent of large bakeries' volume consist of private label, while this constitutes a much larger proportion of the smaller bakers' volume [12, p. 68]. In addition, several large dairies report only about 1 percent of their fluid milk volume is private label [10, p. 144].

On the other hand, core manufacturers have experienced a substantial increase in advertising expenditures to an average of over 3.2 percent of sales in 1965. This reflects the movement of core manufacturers away from standardized commodities toward greater emphasis on product development and branded consumer items. Buzzell and Nourse [3] document the source of major product innovation in 21 food categories. Their chronology is divided into four periods: early development, prior to 1900; pre-World War II, 1900–1938; World War II, 1939–1945; post-World War II. The authors conclude:

> Comparison of each period with earlier periods clearly shows the shift from individual inventors and small companies to large food processors as the primary source of new products . . . the dominance of the large firm is clear cut after 1960. Large processors introduced all nine of the product innovations between 1960 and 1964 . . . [3, pp. 87 and 91].

Competitive behavior of core and fringe manufacturers is further contrasted by observing changes that occur in products of small firms acquired by large conglomerate firms. Table 3 indicates that in the postwar period, brands of acquired firms receive substantially greater advertising support than before the merger. Sixty-five brands of 39 companies received almost double the advertising support in the first full year after acquisition than they had received in the period immediately prior to the acquisition. These data indicate that the cost of continually developing and introducing new products precludes this activity for most noncore manufacturers.

Food distribution

Structure.—Core distributors are defined as the 10 largest retail food chains and are called national chains even though none operates in all metropolitan markets. In 1968 these firms had about 12,700 grocery stores and approximately 30 percent of total U.S. grocery store sales [4, p. 12].

Successful fringe distributors, reflecting their merchandising expertise, tend to have larger, higher volume supermarkets than do core distributors. Only two of the top 10 chains had average supermarket sales of $2,000,000 or more in 1968, while 55 of the 11–100 largest chains had average supermarket sales of this size [4, pp. 12–13]. A tabulation by *Chain Store Age* lists 50 local chains, ranging in size from 4 to 22 supermarkets, that had average supermarket sales between $2,000,000 and $4,500,000 [4, p. 14].

Evidently, consumers' desire for a variety of product-service combinations precludes either core or fringe distributors from dominating most local markets. For 22 metropolitan areas studied, the four largest firms were almost evenly distributed between core and fringe firms—2.1 to 1.9 [5, pp. 20–26]. In a study of 218 local markets the 20 largest food distributors experienced a net decline in market position between 1954 and 1963, while 228 local firms in these markets had a net increase in market position [14, p. 53]. Firms of all sizes experience great difficulty in maintaining local market shares above 20 to 25 percent. Between 1958 and 1963 the number of instances in which local and national firms had market shares of 20 percent or more in 218 markets dropped from 71 to only 51 [14, p. 53]. Core

Table 3. Changes in advertising support for brands acquired by large food manufacturers, 1950–1964

Year	Network T.V.	Spot T.V.	Magazines	Newspapers	Total
	millions of dollars				
Year prior to acquisition	5.4	7.9	6.2	3.2	22.7
First full calendar year after acquisition	7.9	17.1	8.2	9.8	43.0

Source: [15, p. 126].

distributors have grown primarily by expanding into additional market areas. In 1948, 9 leading food chains operated in a total of 392 metropolitan areas, while in 1963 these firms operated in 518 metropolitan areas [14, p. 161].

Market behavior.—Core distributors have a comparative advantage in preretail operations which are subject to significant economies of scale. Most warehouse economies are realized by operations of $100 million or more annual retail sales. However, to obtain available economies of manufacturing and private-label operations, annual retail sales of over one-half billion dollars may be necessary [14, pp. 52, 228].

The close association between core distributors and manufacturing and private-label operations further indicates substructure specialization. In 1963 the 8 largest distributors accounted for over $1.2 billion or about 68 percent of the value of food products manufactured by the 40 largest chains, which in turn account for about 90 percent of all food manufactured by distributors [14, p. 76]. In addition, Table 4 indicates that core distributors manufacture a much wider variety of food products than smaller chains. Even when purchasing rather than manufacturing private-label items, core retailers find that to maintain adequate control they must develop detailed product specifications, maintain quality control laboratories, and develop package and label design. Substantial volume is necessary to support this activity.

Domination of private-label sales by core distributors is apparent from Table 5. Total U. S. private-label movement through wholesale organizations for nine product groups is divided by type of distributor. In 1964 chain warehouses and affiliated and independent wholesalers had private label sales in these products totaling $2.2 billion. Corporate food chains accounted for 88.6 percent of this total,

Table 4. Average number of food products manufactured by 40 largest chains, 1960–1963

1963 rank	Average number of food products (five-digit) manufactured during:					
	1930	1940	1950	1954	1958	1963
4 Largest	18.3	22.3	29.3	31.0	32.0	33.5
5 to 8 Largest	6.7	9.7	15.8	18.8	21.5	22.8
9 to 20 Largest	1.9	1.9	3.6	4.4	6.8	9.7
21 to 40 Largest	.9	1.9	3.3	3.4	4.5	6.3

Source: [14, p. 80].

Table 5. Private label sales of nine product groups by type of retail organization, 1964

Produce group	Total private label wholesale sales	Type of retail organization			
		Food chains	Voluntary groups	Cooperative groups	Independent wholesalers
	thousand dollars	*Percent of column 1*[a]			
Bakery products	512,179	96.7	2.0	1.2	.1
Weiners	47,808	95.1	2.6	2.2	.1
Dairy products	829,863	93.0	4.5	1.9	.6
Bacon	113,563	92.4	5.2	2.0	.4
Coffee	216,819	90.7	4.5	2.0	2.9
Frozen fruit juices	84,705	83.4	9.6	6.0	1.0
Frozen vegetables	96,154	80.5	9.4	7.8	2.4
Canned fruit	126,226	66.4	15.3	8.4	9.9
Canned vegetables	166,944	58.9	20.2	9.2	11.7
Totals	2,194	88.6	6.2	3.1	2.1

[a] Percentages may not add to 100 due to rounding. Source: Computed from Tables 2–8 through 2–11 in [16, pp. 20–22].

compared with approximately 47 percent of total grocery store sales.[9] No study has directly estimated the percent of total private-label sales accounted for by the top 10 distributors. A 1962 Federal Trade Commission study, however, shows buyer concentration in the frozen fruit and vegetable industry by type of buyer and type of brand. In 1959 the 10 largest (core) chains accounted for 34 percent of all frozen fruit and vegetable sales by all food stores. In contrast, these 10 chains purchased 61 percent of the products sold under retailers' brands (private label), while accounting for only 20 percent of the products sold under manufacturers' brands, [14, p. 72].

Expertise in preretail operations results in lower store-door costs for core distributors. Table 6 indicates that national chains enjoy 2.4 to 3 percent lower merchandise cost than do fringe distributors. Prices were also compared by type of label for 10 products, for each of which private label items were less expensive than comparable advertised brands. The price difference averaged 20 percent [14, p. 137]. These factors give core distributors a strong base for merchandising their economy appeal.

Fringe distributors are able to overcome much of the core distributors' preretail cost advantage by more effective performance at the retail level. Progressive fringe distributors rely on unique store decor, highly motivated personnel, and innovative merchandising pro-

[9] Food chains' share of private label sales is biased upward, especially for dairy and bakery products, since purchases by affiliated and unaffiliated independent retailers directly from manufacturers that bypass wholesalers are not included.

Table 6. Store-door cost indexes by type of organization (national chain price = 100)

Product type	National chains	Local chains	Affiliated independents	Unaffiliated independents	Food discounters[a]
Weighted:					
Meat......	100.0	99.7	103.9	101.8	108.0
Produce....	100.0	108.8	105.5	98.0	101.7
Grocery....	100.0	101.5	102.3	101.7	100.4
Nonfood....	100.0	104.3	103.3	105.8	103.9
Total	100.0	102.5	103.1	102.4	102.4

[a] Both food chains and affiliated independents are included in this group.
Source: [14, p. 332].

grams. *Progressive Grocer's* "store of the month" award for unusual creativity and leadership in some aspect of supermarket retailing invariably goes to a small- to medium-size independent or local chain. Empirical evidence of superior efficiency with which fringe distributors perform the retail function is presented in a National Commission on Food Marketing study of two markets, in which all types of fringe distributors had gross margins 2 to 5 percentage points lower than the national chains [14, p. 328]. This superior performance at the retail level reduces the cost advantage of core distributors.

Exceptions

Several questions are left unanswered. Some small manufacturing firms bring out new product ideas. The processes that explain the origin of new product ideas are more complex than current capacity to do research. In today's food market, however, it doesn't matter where new product ideas originate; their market introduction almost always requires the promotional abilities of large firms.

There are industries and products where the dichotomy between economy and product progress channels does not exist. Fluid milk and fresh meat industries are examples. Both have specialized processing industries with oligopoly structures, but the emphasis on product progress doesn't mean much. While separate industries may have inherent differences in potential new product possibilities, this lopsided performance in favor of efficiency at the expense of product progress probably results from rigid product definitions for milk and grades of meat. Canned soup is another example. Here the private-label alternative never developed to any significant degree. This seems to result from the unusually effective cost control in the manufacture and distribution of soup.

Cereal is another exception from the tendencies indicated in the model. Here, again, private label alternatives have never amounted to very much. Performance is lopsided in favor of product progress at the expense of economy. Cost control is certainly not the basis for this exception. High selling costs as well as high manufacturer profits provide plenty of room for the economy emphasis of private label. While private-label cold cereal has been consistently offered at substantial savings, its sales have not taken over 5 percent of industry volume. For some reason the economy appeal means little to most consumers in this particular industry. Probably it is explained by the extensive role children play in the selection and consumption of this product. Response to the economy appeal is probably a rather adult behavior pattern.

While this analysis does not engage all dimensions of the model and some exceptions exist, the case for a strong tendency for substructure specialization is impelling. Large manufacturers have clear advantages in the promotion aspects of new product business. Large distributors evidence a consistent commitment to cost-reducing integration schemes. Results of these activities are carried through to competition for consumer patronage.

Implications

These ideas represent a major reorientation of conventional explanations of industry structure–behavior–performance relationships. The implications of these behavioral tendencies should be developed against two separate points of view: implications for industrial organization theory and implications for the domestic food industries.[10]

Implications for theory

Patterns of economic activity presented here depend upon the following principles:

(1) The market place is a valid reflection of society's preferences among performance goals.

(2) Conflicting performance goals (economy

[10] In addition, implications may be drawn for less-developed countries. A distribution oligopoly with its tendency to emphasize low prices and to develop streamlined and efficient supply systems would seem to have much to offer in situations where productivity is generally low. Research concerning goals for market structure in less-developed countries is proceeding with extremely undeveloped hypotheses. Although virtually no data are available on this subject, we think this hypothesis is worth suggesting.

and product progress) can be achieved in a market economy only if substructures in the system specialize to activities compatible with a particular goal.

(3) Manufacturing oligopoly tends toward nonprice competitive strategies.

(4) Distribution oligopoly tends toward price-competitive strategies.

On the basis of these principles, certain methods or directions of industry analysis seem particularly attractive. In the first place, the firm or industry is not an adequate unit of investigation. If separate industries or substructures specialize in different activities to complement or offset others, the total pattern of interaction and behavior cannot be observed through the study of one industry. This is a substantial basis for the sector approach to economic research.[11]

Secondly, the application of universal performance criteria across all substructures seems inappropriate. While price fixing or false advertising should rightly be illegal per se, there does not seem to be any single norm for criteria such as profit rates or advertising expenditures. Industry analysis should thus give primary consideration to encouraging a competitive environment in which substructures of both channels can compete.

Probably the most unusual aspect of this conceptual construction is the "distribution oligopoly." Such a structure did not exist before this century. It first began to exert influence on food markets around 1920. It is not surprising that this substructure has received little attention in the stream of classical economic literature. On the other hand, it seems compatible with economies having high consumer income and mass production of consumer goods. While distribution oligopolies have achieved their most advanced development in food industries, they now spread far beyond this sector, particularly into the general merchandise discounting field. Distribution oligopolies are probably a structural characteristic of the more mature industry sectors.

Implications for domestic food industries

There are implications for private planning of firms in domestic food industries. Greater specialization seems increasingly likely to accompany the forming of larger firms and more concentrated structures in processing and distribution. This will lead to a condition where all products are differentiated. They will not be all premium products. Oligopoly processors will differentiate premium and progressive products. Oligopoly distributors will differentiate their private labels around the economy image. Products without the powerful differentiating capabilities of one or the other will drop from the market.

The most significant implications for the domestic food industries, however, pertain to public policy. Often antitrust issues in various food processing industries have been addressed with no consideration given to the role of the private-label activity of major distributors. The tendencies toward nonprice, quality-oriented, competitive activities of oligopoly processors have been seen as depriving society of the price-competitive alternative. That the distributive oligopoly provided this alternative was not taken into account. As a result, aggressive antitrust decisions have been handed down in industries where the combined strategies of the whole sector were surprisingly responsive to both efficiency and progress norms.

An interesting case in point is the dairy industry. Merger guidelines for this industry were drawn up in an effort to keep the structure close to the atomistic structure most likely to compete through price [9]. The basis for this policy was drawn from study of structure and behavior of the dairy processing industry. No mention is made of the private-label programs of food distributors. There is no behavior characteristic of this industry that places so important a competitive constraint on dairy processors.

Large processors cannot be expected to seek consumer attention primarily through price. The structural features of the private-label program are superior there. The major processor should use his reasearch and promotion capability to advance product progress qualitatively. Only he can do this. If one were to fault dairy industry performance, it would not be the lack of the price-competitive alternative. That is well-done and widely available. The more serious shortcoming is in the product progress area. The antitrust harassment is probably at cross-purposes with product progress. It leads major firms, with the capability to introduce new products to an affluent society, to diversify out of dairy.

[11] While the theoretical framework underlying industrial organization places considerable emphasis on the market as a unit of inquiry rather than the firm or industry, in application researchers frequently give undue emphasis to structural elements of only one side of the market.

Conclusions

The food industry provides an opportunity without parallel for studying industry structure and behavior. This study suggests a type of market-oriented interaction pattern very broad in scope. This interaction pattern extends beyond the firm or industry. It involves specialization of some industries to offset or complement others. For this reason the full picture of competitive response may not be observed in the study of a few units of the processing-distribution complex. These patterns of specialization and complementarity are necessary if society's multidimension performance goals are to be achieved.

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Computing Equilibrium Solutions for Imperfectly Competitive Markets*

YAKIR PLESSNER

In most theoretical as well as empirical studies the conditions of free competition are assumed, and thus conclusions are subject to competitive behavior. In the real world, however, noncompetitive structures are quite common and deserve not less but, from several viewpoints, more attention than competitive ones. Assuming a linear demand system and constant returns to scale and using quadratic programming, it is shown how partial market equilibria for various leading firm and monopolistic structures can be computed. The operational usefulness of such computations is demonstrated via an application to an agricultural industry.

MICROECONOMIC THEORISTS have devoted a great deal of thought to problems of behavior and equilibrium positions under various market structures. The competitive structure has received by far the most attention and research in this direction has attained a high level of sophistication, including the computation of fixed points for competitive economies.

This paper deals only with partial equilibria and uses a more conventional armory. Its main objective is to treat the more neglected but rather common structures of imperfect competition. As Kottke [4] has pointed out, knowledge of equilibrium positions in noncompetitive markets is important in many practical situations and particularly may be very useful in the formulation of economic policy. Kottke mentions quadratic programming as a promising tool, and that is the approach taken here.

We present and discuss the properties of a series of quadratic programming models, each of which represents a particular market structure. We shall show that the solutions obtained in these models are, under certain assumptions, equilibrium solutions for the markets under consideration, and we shall then report the results of applying some of these models to an agricultural industry and present some conclusions that can be drawn from such an application.

Quadratic programming models have been presented and discussed at various levels of generality [2, 9, 10, 11]. Applications, primarily to situations of competition, and recently also to monopolistic structures, are also available [3, 5, 6]. Thus, devoting a paragraph to the competitive case, we shall describe in detail the construction of noncompetitive models. In particular, we focus attention on the leading firm and complete monopoly structures.

In all cases we consider a sector of the economy that produces n goods and is small enough for consumer income and prices of all other goods to be taken as given. In other words, we are solely concerned with partial equilibria. It is also assumed that the production process can be described by linear production activities. We adopt the following notation, using lower case letters to denote column vectors, capital letters for matrices, and Greek letters to represent scalars:

- x = level of output of the n goods;
- b = available quantities of limited (fixed in the short run) production factors, m in number;
- A = input matrix, of size $m \times n$, indicating inputs of the limited factors per unit level of x;
- p = price vector of the n goods;
- c = "variable" costs per unit level of x;
- u = imputed ("shadow") price vector of the limited factors.

It is assumed that price formation[1] in the market can be described by

$$p = a + Dx, \tag{1}$$

where a is an n-vector of constants and D is an $n \times n$ negative semi-definite matrix.[2]

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[1] The term "price formation" instead of "demand" is used intentionally, since theory teaches that demand is a function in which the quantity of the good demanded depends on all prices.

[2] The matrix D is called negative semi-definite if $(D+D')$ is negative semi-definite. D need not be symmetric; the

The Models

Free competition

We consider K firms which can produce the n goods. Problem I is to find nonnegative vectors x_k, $k=1,2,\cdots,K$ and u which maximize

$$f_1(x_1,\cdots,x_K,u)$$

$$= a'\sum_k^K x_k + \sum_k^K\sum_s^K x_k'Dx_s - \sum_k c_k'x_k - b'u \tag{2}$$

subject to

$$\sum_k A_k x_k \leqq b \tag{3}$$

$$\sum_k Dx_k - A_k'u \leqq c_k - a \qquad k = 1, 2, \cdots, K \tag{4}$$

The first two terms of the maximand (2) represent total revenue, the third term constitutes variable costs, and the last term represents returns to fixed factors. Thus, (2) is the profit function. It is important to note that while u is a vector of returns to the industry as a whole, it is a vector of alternative costs to the individual firm. Hence, the set of constraints (4) requires that marginal costs do not exceed price for any firm and good.

Denoting the maximizing values by $(x_1^0,\cdots,x_K^0,u^0)$, the following results can be proved:[3] (a) $f_1(x_1^0,\cdots,x_K^0,u^0)=0$; (b) for the ith element of x_k, x_{ik}, it is true that $x_{ik}^0>0$ implies that the price of i equals the marginal costs of its production ($p_i=MC_{ik}$) and $MC_{ik}>P_i$ implies $x_{ik}=0$; (c) letting z_k^0 denote the portion of b utilized by firm k, the solution $(\bar{x}_k,\bar{z}_k)$ of the problem

$$\max p^{0\prime}x_k - u^{0\prime}z_k$$

subject to

$$A_k x_k - z_k \leqq 0$$
$$x_k, z_k \geqq 0$$

is such that $\bar{x}_k=x_k^0$, $\bar{z}_k=z_k^0$.[4]

assumption implies that all the diagonal elements are negative, and is necessary to ensure that every local optimum is also a global one. For a more complete discussion see [8, 10].

[3] Detailed proofs can be found in [8, 9]. The proofs are based on the fact that Problem I is self-dual i.e., the shadow prices of (3) equal u^0 and those of (4) equal $x_1^0,\cdots,x_K^0$.

[4] This is the decentralization property.

It follows from the above that (3) and (4) are not just any sets of constraints but rather the usual optimality conditions for competitive behavior. This raises the possibility that problems like Problem I do not have any feasible solutions that are not optimal.[5] The following numerical example helps to resolve such doubts. Let

$$A = \begin{bmatrix} .5 & 1 \\ 2 & .5 \end{bmatrix}, \qquad D = \begin{bmatrix} -.1 & 0 \\ 0 & -.2 \end{bmatrix},$$

$$b = \begin{bmatrix} 2 \\ 3 \end{bmatrix}, \qquad (a-c) = \begin{bmatrix} .05 \\ .10 \end{bmatrix}$$

$$x = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, \qquad u = \begin{bmatrix} 0 \\ 0 \end{bmatrix}.$$

It can be easily verified that (x, u) is feasible and $f_1(x,u)=-.15<0$, which is not optimal.

Leading firm

In order to facilitate discussion of the more complex quadratic programs which follow, we deviate from the above assumptions and notations and resort to the usual classroom analysis[6] of the leading firm structure, using some simplifying assumptions that will enable us to concentrate on the main points.

Consider a single product market. Let ξ_1 be the output of the leader, ξ_2 be the aggregate output of the competitive followers, and $\xi=\xi_1+\xi_2$. Let α_0, α_1 be constants such that

$$\Pi = \alpha_0 + \alpha_1\xi = \alpha_0 + \alpha_1\xi_1 + \alpha_1\xi_2, \tag{5}$$

where Π is the price of the good under consideration. Next, suppose the leading firm enjoys constant returns to scale, so that marginal costs are a constant, γ_1.

Assume that the aggregate supply curve of the competitively behaving firms is given by

$$\gamma_2 = \beta_0 + \beta_2\xi_2, \qquad \xi_2 > 0. \tag{6}$$

From (5), per unit profits of the leading firm are given by

$$\mu_1 = \Pi - \gamma_1 = \alpha_0 + \alpha_1\xi_1 + \alpha_1\xi_2 - \gamma_1. \tag{7}$$

In order to derive the necessary conditions for optimality, we shall now assume that at equilibrium, $\xi_2>0$. This assumption, to be dropped later, is made to avoid complications

[5] I am indebted to D. Levhari for calling my attention to this apparent difficulty.

[6] See for instance Leftwich [7], particularly p. 246.

resulting from the piecewise linearity of the demand function facing the leader.

The necessary condition for optimal output by the leader is then

$$\alpha_0 + 2\alpha_1\xi_1 + \alpha_1\xi_2 + \alpha_1\xi_1 \frac{d\xi_2}{d\xi_1} - \gamma_1 = 0$$

or

$$\alpha_0 + \alpha_1\xi_1 + \alpha_1\xi_2 - \gamma_1 = -\alpha_1\xi_1\left(1 + \frac{d\xi_2}{d\xi_1}\right) \tag{8}$$

From (7) and (8),

$$\mu_1 = -\alpha_1\xi_1\left(1 + \frac{d\xi_2}{d\xi_1}\right)$$

and hence total profits of the leader are

$$\mu_1\xi_1 = -\alpha_1\xi_1^2\left(1 + \frac{d\xi_2}{d\xi_1}\right). \tag{9}$$

At equilibrium, we have $\gamma_2 = \Pi$ or, by (5) and (6),

$$\beta_0 + \beta_2\xi_2 = \alpha_0 + \alpha_1(\xi_1 + \xi_2). \tag{10}$$

It follows from (10) that

$$\frac{d\xi_2}{d\xi_1} = \frac{\alpha_1}{\beta_2 - \alpha_1} \tag{11}$$

and hence (9) becomes

$$\mu_1\xi_1 = -\frac{\alpha_1\beta_2}{\beta_2 - \alpha_1}\xi_1^2. \tag{12}$$

Also, by an argument similar to the one employed for the leader, total (normal) profits of the competitors are given by

$$\mu_2\xi_2 = \tfrac{1}{2}\beta_2\xi_2^2. \tag{12a}$$

Figure 1 depicts the classroom solution of the leading firm case, where AB represents the demand faced by the leader for $\Pi > \beta_0$ and AC is the marginal revenue derived from it. Algebraically, the solution is obtained by solving the system (8), (10), and (11). This yields

$$\xi_1 = \frac{\alpha_1(\beta_0 - \gamma_1) + \beta_2(\gamma_1 - \alpha_0)}{2\alpha_1\beta_2} \tag{13}$$

$$\xi_2 = \frac{\alpha_0 - \beta_0}{\beta_2 - \alpha_1} + \frac{\alpha_1}{\beta_2 - \alpha_1} \cdot \frac{\alpha_1(\beta_0 - \gamma_1) + \beta_2(\gamma_1 - \alpha_0)}{2\alpha_1\beta_2} \tag{14}$$

Note that in Figure 1 the triangles $\gamma_1 AG$ and $\beta_0 \Pi F$ represent (12) and (12a), respectively.

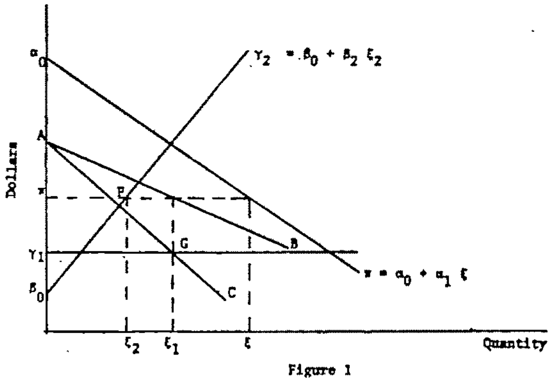

Figure 1

Turning to the programming formulation of the single commodity case, consider the problem of finding ξ_1, ξ_2 which maximize

$$[(\alpha_0 - \gamma_1)(\alpha_0 - \beta_0)]\begin{bmatrix}\xi_1\\ \xi_2\end{bmatrix} + [\xi_1 \ \ \xi_2] \cdot \begin{bmatrix}\alpha_1\left(1 + \dfrac{\beta_2}{\beta_2 - \alpha_1}\right) & \alpha_1 \\ \alpha_1 & (\alpha_1 - \beta_2)\end{bmatrix}\begin{bmatrix}\xi_1\\ \xi_2\end{bmatrix} \tag{15}$$

subject to

$$\alpha_1\left(1 + \frac{\beta_2}{\beta_2 - \alpha_1}\right)\xi_1 + \alpha_1\xi_2 \leq \gamma_1 - \alpha_0 \tag{16}$$

$$\alpha_1\xi_1 + (\alpha_1 - \beta_2)\xi_2 \leq \beta_0 - \alpha_0. \tag{17}$$

The best way to interpret (15) is to break it down into its various components. These will be seen to be total revenue, total costs, and total profits.

Total revenue is given by

$$\alpha_0(\xi_1 + \xi_2) + \alpha_1\xi_1^2 + \alpha_1\xi_2^2 + 2\alpha_1\xi_1\xi_2; \tag{15a}$$

total costs by

$$\gamma_1\xi_1 + \beta_0\xi_2 + \tfrac{1}{2}\beta_2\xi_2^2; \tag{15b}$$

and, from (12) and (13), total profits are given by

$$-\alpha_1\xi_1^2\left(1 + \frac{\beta_2}{\beta_2 - \alpha_1}\right) + \frac{1}{2}\beta_2\xi_2^2. \tag{15c}$$

Subtracting (15b) and (15c) from (15a), we obtain (15).

Turning to the constraints, (16) is (8) written

in the form of an inequality with the help of (11), while (17) bears the same relation to (10). Since our problem is self-dual in the sense explained above, it follows that if ξ_1 and ξ_2 are both positive, (16) and (17) will hold as equalities and thus the program's solution will coincide with (13) and (14).

The optimal value of (15) is zero, as it should be because of the structure of (15). The interesting point is that there exists an overall function whose maximization leads to market equilibrium.

The use made of the classroom case of the leading firm was intended only to facilitate the discussion of the programming approach. We are now ready to return to the activity analysis structure and omit the assumption of linear marginal cost schedules. Moreover, henceforth we do not assume knowledge of the supply function of the competitive followers.

More specifically, it is well known from linear programming that marginal cost functions in the present context have the general form depicted by the curve $\pi_1 A$ in Figure 2. The line segments BB and CC and the ray emanating from D represent the derived demand facing the leader, while BB' and $C'C'$ depict the corresponding marginal revenue. The equilibrium solution is $(\pi^0, \xi_1^0, \xi_2^0)$.

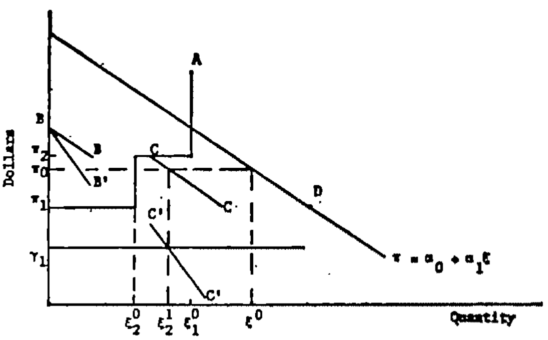

Figure 2

We observe next that the slope of BB as well as CC is α_1; that is,

$$\frac{d\pi}{d\xi_1} = \frac{d\pi}{d\xi} \tag{18}$$

for every point for which the left hand side of (18) is defined. Now, $d\xi = d\xi_1 + d\xi_2$ by definition. Hence,

$$\frac{d\xi}{d\xi_1} = 1 + \frac{d\xi_2}{d\xi_1}\,.$$

But from (18)

$$\frac{d\xi}{d\xi_1} = 1,$$

which implies

$$\frac{d\xi_2}{d\xi_1} = 0 \tag{19}$$

whenever the latter is defined.

A difficulty arises when, for instance, $\pi = \pi_2$. The problem is created by the fact that as $\pi \to \pi_2$ from below, $\xi_2 = \xi_2^0$ while as $\pi \to \pi_2$ from above, $\xi_2 = \xi_2^1$ (see Figure 2). In the programming context, a solution in which $\pi = \pi_2$ is a degenerate solution. We shall thus restrict our discussion henceforth to nondegenerate solutions. It should be noted that from now on we need not assume $\xi_2 > 0$, since all nondifferentiable points have already been ruled out by the last assumption.

Proceeding now with the aid of (19), we can replace (8) by

$$\alpha_0 + \alpha_1\xi_1 + \alpha_1\xi_2 - \gamma_1 = -\alpha_1\xi_1 \tag{20}$$

and (9) by

$$\mu_1\xi_1 = -\alpha_1\xi_1^2. \tag{21}$$

These results can now be generalized. Let $x = x^1 + x^2$, where x^1 is the output vector of the leader and x^2 that of the followers. Correspondingly, we define c^1, c^2 as costs; A^1, A^2 as technology matrices; b^1, b^2 as resource vectors; and u^1, u^2 as "shadow prices", relative to b^1 and b^2. The demand system is given by

$$p = a + D(x^1 + x^2).$$

Problem II is to find nonnegative x^i, u which maximize

$$\begin{aligned} &f_2(x^1, x^2, u^1, u^2) \\ &\quad = (a - c^1)'x^1 + (a - c^2)'x^2 + x^{1\prime}Dx^1 \\ &\qquad + x^{1\prime}Dx^2 + x^{2\prime}Dx^1 + x^{2\prime}Dx^2 \\ &\qquad - b^{1\prime}u^1 - b^{2\prime}u^2 + x^{1\prime}D'x^1, \end{aligned} \tag{22}$$

subject to

$$A^i x^i \leqq b^i \qquad i = 1, 2, \tag{23}$$

$$(D + D')x^1 + Dx^2 - A^{1\prime}u^1 \leqq c^1 - a, \tag{24}$$

$$Dx^1 + Dx^2 - A^{2\prime}u^2 \leqq c^2 - a. \tag{25}$$

In (22) the term $x^{1\prime}D'x^1$ is the equivalent of the first term of (15c);[7] (24) corresponds to (16)

[7] Except for the sign, since (15c) appears in (15) with a negative sign.

and (20); and (25) to (17). That is, $(-x^{1\prime}D'x^1)$ represents total monopolistic profits of the leading firms; (24) requires that the leaders' marginal revenue does not exceed their marginal cost; and (25) prohibits the followers' marginal cost from falling short of the price realized by them. This interpretation of $(-x^{1\prime}D'x^1)$ can be verified if one premultiplies (24) by x^1 and rearranges terms. This yields

$$(26)\quad \begin{aligned} &x^{1\prime}a + x^{1\prime}Dx^1 + x^{1\prime}Dx^2 \\ &\qquad - x^{1\prime}(c + A^{1\prime}u^1) \le - x^{1\prime}D'x^1. \end{aligned}$$

The left hand side of (26) represents profits; hence, if (26) holds as a strict equality, its right hand side must equal profits. That (26) will, in fact, hold as an equality for optimal x^1, x^2, u^1 follows from the self-duality.

It is obvious from the formulation that the only possible differences between leader and followers arise from technology and availability of resources. Technological differences are reflected in differences between $A^{i\prime}$s and $c^{i\prime}$s whereas the $b^{i\prime}$s represent differences in resources. It is therefore evident that in general we will find $u^1 \neq u^2$. This gap can serve as a measure of the losses to the economy due to monopolistic power and as a guide for taxation. It should be noted, however, that (23) could be replaced by

$$\sum_{i=1}^{2} A^i x^i \leqq b$$

in which case we would have in (22) $(-bu)$ instead of $(-b^1u^1 - b^2u^2)$; and $A^{1\prime}u^1$, $A^{2\prime}u^2$ in (24) and (25) would become A^1u' and $A^{2\prime}u$. That is to say, a noncompetitive structure of the product market does not necessarily either imply or result from a noncompetitive structure of the factor market. This is also true of the problems below.

Monopoly

The simplest case is that of pure monopoly. Problem IIIa consists of finding a nonnegative x which maximizes

$$f_3(x) = (a - c)'x + x'Dx$$

subject to

$$Ax \leqq b$$

That the solution is in fact a monopolistic one can be verified through an examination of the dual to Problem IIIa.[8]

A little more involved is the case in which only some of the goods are monopolized while others are produced under competitive conditions. Consider the partition $x' = (x^{1\prime}\ x^{2\prime})$ where the superscript "1" denotes monopolized and the superscript "2" competitive industries. This partition induces the following further partitions:

$$\begin{bmatrix} p^1 \\ p^2 \end{bmatrix} = \begin{bmatrix} a^1 \\ a^2 \end{bmatrix} + \begin{bmatrix} D^{11} & D^{12} \\ D^{21} & D^{22} \end{bmatrix} \begin{bmatrix} x^1 \\ x^2 \end{bmatrix}$$

where D^{ij} is the matrix of partial derivatives of prices of goods in group i with respect to quantities produced in group j.

Problem IIIb consists of finding nonnegative x^i, u^i, $i = 1, 2$, which maximize

$$\begin{aligned} &f_4(x^1, x^2, u^1, u^2) \\ &\quad = \sum_{i=1}^{2} \left[(a^i - c^i)'x^i + \left(\sum_{j=1}^{2} x^{i\prime} D^{ij} x^j \right) - b^{i\prime}u^i \right] \\ &\quad\quad + x^{1\prime}D^{11\prime}x^1 \end{aligned}$$

subject to

$$A^i x^i \leqq b^i, \qquad i = 1, 2$$

$$(27)\quad \begin{aligned} &\begin{bmatrix} D^{11} + D^{11\prime} & D^{12} \\ D^{21} & D^{22} \end{bmatrix} \begin{bmatrix} x^1 \\ x^2 \end{bmatrix} \\ &\qquad - \begin{bmatrix} A^{1\prime} & 0 \\ 0 & A^{2\prime} \end{bmatrix} \begin{bmatrix} u^1 \\ u^2 \end{bmatrix} \leqq \begin{bmatrix} c^1 - a^1 \\ c^2 - a^2 \end{bmatrix} \end{aligned}$$

The first constraint in (27) prescribes that marginal revenues in monopolized industries may not exceed marginal costs, while the second constraint is similar to (4). The expression $(x^1D^{11\prime}x^1)$ represents monopolistic profits (cf. [26]).

The above formulations demonstrate how the technique may be used to "imitate" those structures that we have dealt with; it may be extended to other structures, and we shall now proceed to indicate the usefulness of the proposed approach.

Application

Three of the above models were applied to the apple and pear markets in Israel. These two fruits are closely related, since they compete strongly both for the consumer's budget and for cold storage facilities. Plantations of both have undergone considerable expansion in recent years, and it is therefore probable that there will be a substantial reduction in prices, particularly of pears.

[8] This is the only problem for whose solution self-duality is not required.

The market for both fruits is currently organized along leading firm lines. The leader is a marketing cooperative that controls about 60 percent of the harvest. The remainder is marketed through a multitude of wholesalers. However, a fruit marketing board is to be established which will have legal power to dictate marketing quotas and might thus reconstruct the market along monopolistic lines.

The present situation and the anticipated changes led us to attempt to compute equilibrium prices for four possibilities: free competition; a leading firm structure; monopoly for apples only; complete monopoly. Linear "demand" functions were estimated and Problems I, II, IIIb, and IIIa were solved for this industry. It was assumed that the total yields are given, the difference between leader and followers being in the total product at the disposal of each. The results are given in Table 1.

As can be seen, the quantities of pears in Problem IIIb are not the same as in Problem I, while the prices are identical. The reason for this is that since the marginal costs are the same in both cases, so are the prices. However, since in Problem IIIb the quantity of apples is less than in Problem I, the price of 5.5 cents per pound in IIIb is reached for a greater quantity of pears than in I. The basic reason is that price cross-elasticities are negative.

One kind of information that is of interest is the loss of welfare due to monopoly. This loss was calculated for the transition from Problem I to Problem IIIa via Problem IIIb. In calculating this loss, we follow Berry [1], who has shown that the loss of welfare in terms of the sum of consumers' and producers' surplus can be extended to cases of interrelated commodities.

Table 1

Problem	Variable	Apples	Pears	Total
I	x^*	159.6	78.9	—
	p^*	12.1	5.5	—
	xp^*	19.3	4.3	23.6
II	x^1	95.8	9.5	—
	x^2	63.8	37.1	—
	x	159.6	46.6	—
	p	15.1	16.4	—
	xp	24.1	7.6	31.7
IIIb**	x	110.9	81.0	—
	p	17.4	5.5	—
	xp	19.3	4.5	23.8
IIIa	x	144.6	20.0	—
	p	19.8	24.1	—
	xp	28.6	4.8	33.4

* Quantities are in million pounds, farm prices in cents per pound, and revenues in million dollars.
** Monopoly in apples.

In these terms, the loss due to a monopoly in apples alone is approximately 1.654 million dollars while the loss from a simultaneous monopolization is about 7.932 million dollars. In addition, some 10 million dollars are passed from consumers to producers, so that the loss to consumers is, in our case, almost 18 million dollars (as marginal costs are constant, and hence producers' surplus is zero under competition). This amounts to an average loss of $6.3 per capita per year.

Our application was intended primarily as a demonstration of the models developed. It was performed under extremely simplified assumptions and should not lead to practical conclusions regarding the market under consideration. In particular, the demand estimates used here are outdated, since they were obtained before the June 1967 war. We thus hope that more elaborate studies will follow.

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A Dynamic Economic Model of Pasture and Range Investments*

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The traditional economic replacement problem is extended to accommodate a situation where quasi-rents of future replacements are influenced by replacement age of the currently held asset. This generalized replacement model is applied to optimal timing of the clearing of brush and scrub timber from pasture and range. Dynamic programming is applied to the problem and the structure of the decision rule analyzed. An approximately optimal decision rule is deduced by an analysis of the limiting behavior of the optimal policy. An illustrative example is given for pinyon-juniper control in southwestern United States.

THE PROBLEM OF choosing optimal frequencies for long-term improvements in pasture and range is of widespread importance, extending from the arid western to the humid eastern United States. A discussion of this problem, particularly as it is exemplified by pinyon-juniper encroachment in the Southwest, is given by Cotner [9]. Brush and noncommercial timber are competitors for pasture in much of the Southeast, presenting a problem comparable to that of pinyon-juniper in the Southwest. The pasture gradually deteriorates as brush and timber cover more and more of the land area. Chemical spraying, bulldozing, burning, or other methods for destroying the brush and timber will rejuvenate the pasture and start a new cycle of first increased pasture productivity and ultimately decreased productivity caused by new brush and timber. Of course, the removal of brush and timber may be associated with other investments such as fertilization and seeding.

Optimal frequency of the renovation process poses an interesting problem in economic dynamics. In most respects it is an added complexity to the classical replacement problem [5, 10]. Within the context of replacement theory, we have a situation where replacement age of an asset influences the quasi-rent functions of assets following in the chain of replacements. The traditional replacement model assumes no such relationship among the assets that follow one another as replacements; i.e., the only argument assumed to be in the quasi-rent function is age of the asset currently held. The more complicated situation encountered in many pasture and range investments requires that the counterpart to replacement age of the currently held asset enter in the quasi-rent function of at least the immediately following replacement and possibly in succeeding replacements. Thus, we have a much more dynamic relationship than in the common replacement model.

The complex replacement problem dealt with in this article appears to be quite unique to agriculture, or at least to biological processes. Only pasture and range improvements are analyzed here, but an extension of the model would permit analysis of crop rotations. Another area for which the same basic approach could be used is in the analysis of optimal timber rotations where multiple age stands are mixed together to fully exploit available radiation, water, and other nutrients.

In an application to pinyon-juniper control in the Southwest, Cotner was apparently the only one thus far to have dealt with this extension of the ordinary replacement problem. However, his method of determining the optimal length renewal period was not very satisfactory. His stated criterion [9, p. 743] was maximization of the internal rate of return on the investment, but he contradicted this criterion by discounting benefits at fixed interest rates. Not only that; the basis of achieving his criterion was supposedly a rule given by Boulding [4] for point-input-point-output assets such as wine or timber, which are a simplified case of the classical replacement problem. There were several other simplifying assumptions in Cotner's work, but they seem relatively unimportant compared with the ambiguity of his criterion function and the "necessary" conditions used to optimize it.

We begin with a precise statement of the problem under the assumption of a first-order dependence structure in the quasi-rent func-

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tions. Next, the problem is formulated in a dynamic programming framework and the structure of the solution examined. Then asymptotically optimal decision rules are examined and evaluated as approximately optimal decision rules in general. Higher order dependence structures in the quasi-rents are dealt with in dynamic programming formulations. Finally, an illustrative example is presented, based largely on Cotner's data for pinyon-juniper.

A Markovian Model of Pasture and Range Renewal

Renewal cycle is defined as the length of period beween two investments in pasture or range improvement, of a major type such as removal of scrub timber and brush. In the completely general case the length of the current renewal cycle affects quasi-rents in all future renewal cycles. If T_j is the length of the renewal period for the jth renewal, then T_j appears in the quasi-rent function of cycles $j+1, j+2, \ldots$ A Markovian or first-order dependence structure would limit T_j to an argument of the quasi-rent function in only cycle $j+1$. A Markovian structure is assumed for now, but it will be shown how to accommodate more general dependence structures later. If the optimal renewal cycles are relatively long, one would expect the Markovian assumption to be quite palatable, since the influence of any earlier renewals would have considerable time to dissipate.

With our assumption of Markovian dependence in the quasi-rent functions, we have two arguments in the quasi-rent function associated with a particular renewal cycle. Let u be length of the previous cycle and v the number of years since the last renewal. As u is increased, holding v constant, brush and timber deteriorate the pasture to a greater extent before their removal and thus reduce quasi-rents in the renewal cycle after their removal. Therefore, u reflects the lagged effect of encroachment and the Markovian assumption implies that the lagged effect remains for only one renewal period. Holding u constant, the quasi-rent function first increases as v is incremented from zero and ultimately a maximum is reached from which quasi-rents diminish as v increases further. The interval of increasing quasi-rents with respect to v is a consequence of the forage recovering from the adverse conditions caused by the brush and timber before its removal. The transition to decreasing quasi-rents is at the point where currently encroaching brush and timber overtake the recovery process.

We denote the quasi-rent function by $R(u, v)$, where u and v are as defined above and the cost of control equation is denoted $c(v)$. The variable, v, is essentially age of the current stand of brush and timber, while u is age of the previous stand at the time it was controlled. The quasi-rent function $R(u, v)$ is defined as the maximum net value with respect to variable factors applied to the operation. Any variables, such as stocking rate, which might interact with the rate of encroachment of brush are assumed to be fixed and are not a part of the optimization process.

When economic and biological conditions are such that pasture renewal implies complete reseeding with destruction of any old stand of forage, the lagged effect of the last renewal, reflected in the variable u, is completely wiped out. The current model then degenerates to the ordinary replacement problem, since the quasi-rent function is then merely $R(v)$. Under current technology and prices, it would appear that complete reseeding with a prepared seedbed is economic only on relatively productive sites with adequate rainfall to give a high probability of success.

The methods of control used from one renewal to another are assumed equivalent in physical performance. They need not be identical, except in their effect on the pasture or range.

Length of the renewal cycle is treated as a continuous variable, primarily for convenience of analysis, but the modifications are straightforward to restrict the cycle to integers. In fact, numerical solution of the dynamic programming equation would almost certainly be done with the integer restriction.

Straightforward specification of a present value criterion function and its differentiation with respect to length of renewal cycles yields an intractable difference equation. Therefore, we depart from classical methods and formulate the problem in a dynamic programming model from which inferences are drawn about the dynamic structure of the optimal decision rule. Then necessary conditions are derived for the optimal policy when the process has converged to its asymptotic limit.

A Dynamic Programming Formulation

The approach used here closely parallels that used by the author in analyzing replacement decisions [5], in which the stage of the multi-

stage decision process was defined by the number of replacements remaining to be made within the firm's planning horizon, in contrast to the more orthodox method of using discrete time periods to define the stage of the process [2]. In this application of dynamic programming the stage is defined by the number of pasture renewals remaining in the planning horizon. By defining stages in this way instead of in fixed time periods, the number of state variables is reduced by one under an infinite planning horizon.

We introduce the following notation:

- p = stage of the process, i.e., the number of pasture renewals yet to be made within the planning horizon
- n = number of years remaining in the planning horizon
- T = length of the renewal period associated with stage p
- m = length of the renewal period immediately preceding stage p in time, i.e., the renewal period associated with stage $p+1$
- $f_p(m, n)$ = present value of all quasi-rents from the remainder of the planning horizon; given stage p, n years remaining in the planning horizon, an immediately preceding renewal period of length m, and that an optimal policy is followed.

Application of Bellman's "principle of optimality" [1, p. 83] to the pasture renewal problem gives the recursive equation

$$f_p(m, n) = \operatorname*{Max}_T\left[\int_0^T e^{-ix}R(m, x)dx - e^{-iT}c(T) + e^{-iT}f_{p-1}(T, n-T)\right], \quad 0 \leq T \leq n. \tag{1}$$

The first state variable m is transformed into T and the second state variable n is transformed into $n-T$ by the transition from stage p to stage $p-1$. These transformations are the crux of the dynamic structure of the problem and follow directly from the definitions of m, n, and T. We have tacitly specified the initial position from which the process begins to be the beginning of a renewal cycle, but it is easily shown that this position is arbitrary and does not affect the optimal policy.

As the planning horizon becomes infinite, the second state variable can be deleted since $n-T \rightarrow n$ as $n \rightarrow \infty$ if T is finite. From a practical point of view, the case where T is not finite is of no interest because the solution would imply no pasture rejuvenation, merely the native equilibrium conditions. Assuming $R(m, x)$ and $c(T)$ are bounded functions, $i>0$, and T is bounded, we can apply a general theorem of Bellman [1, p. 121] which implies that $f_p(m, n) \rightarrow f_{p-1}(m, n)$ and the optimal policy function $T_p(m, n) \rightarrow T_{p-1}(m, n)$ as $p \rightarrow \infty$. The optimal policy function is the solution of (1) for given values of p, m, and n. We can write a simplification of (1) under the limiting case where both p and n increase without limit:

$$f(m) = \operatorname*{Max}_T\left[\int_0^T e^{-ix}R(m, x)dx - e^{-iT}c(T) + e^{-iT}f(T)\right], \quad 0 \leqq T \leqq b, \tag{2}$$

where b is an arbitrarily large but finite number. As a consequence of the convergence theorem to which we appealed in deducing (2) from (1), $f(m)$ is a continuous function if $R(m, v)$ and $c(T)$ are continuous.

Either relation (1) or (2) can be solved by numerical methods utilizing an electronic computer [3], but we are also concerned about the structure of the solution and simplified decision rules. At the expense of some well known restrictive assumptions, we can write (2) without the maximum operator and substitute an equation implied by setting the first derivative with respect to T of the expression in brackets equal to zero. Thus,

$$f(m) = \int_0^T e^{-ix}R(m, x)dx - e^{-iT}c(T) + e^{-iT}f(T), \tag{3}$$

$$R(m, T) + ic(T) - c'(T) - if(T) + f'(T) = 0[1] \tag{4}$$

are an alternative for (2) that is more amenable to further analysis. The second-order conditions for a maximum, which must hold together with the necessary conditions of (4), are

$$\partial R(m, T)/\partial T + ic'(T) - c''(T) - if'(T) + f''(T) < 0. \tag{5}$$

[1] We are using the common notation of primes to denote first partial derivatives, e.g., $g'(x) = \partial g/\partial x$.

We are particularly interested in $\partial T/\partial m$ with respect to sign and magnitude because it is the source of inferences about the dynamic behavior of the decision process. Let us return to the notation $T_1, T_2, \ldots$, where T_i is length of the ith renewal period measured with origin at the *beginning* of the planning horizon. Then $\partial T/\partial m$ is equivalent to $\partial T_i/\partial T_{i-1}$. The relationship between T_i and T_{i-1}, say $T_i=\phi(T_{i-1})$, is an implicit one; and for a given value of T_{i-1}, $\phi(T_{i-1})$ implies simultaneous solution for $T_i, T_{i+1}, \ldots$,. However, the Markovian dependence of our criterion function permits this implicit solution for $T_{i+1}, T_{i+2}, \ldots$ to be incorporated in the functional equation $f(T)$. Thus, conceptually at least, we have a first-order difference equation $T_i=\phi(T_{i-1})$ which can be analyzed in general without an explicit algebraic specification of the function ϕ.

Samuelson [11, p. 303] delineates all possible types of qualitative behavior of this function in the neighborhood of an equilibrium. If ϕ' is positive, the approach to equilibrium is asymptotic; if negative, equilibrium is approached by dampened oscillations, assuming a stable equilibrium exists. A necessary condition for stability is "stability in the small" which means movement back toward equilibrium for sufficiently small disturbances from equilibrium [11, p. 262]. Stability in the small implies $|\phi'|<1$. Going back to (3) and (4), we have evidence of stability if $|\partial T/\partial m|<1$; and the sign of $\partial T/\partial m$ indicates whether the equilibrium is approached asymptotically or through dampened oscillations.

Differentiation of (4) yields:

$$\frac{\partial T}{\partial m}=-\frac{\partial R(m,T)}{\partial m}\bigg/\left[\frac{\partial R(m,T)}{\partial T}+ic'(T)-c''(T)-if'(T)+f''(T)\right]. \tag{6}$$

The denominator of the right hand side of (6) must be negative to meet the second-order condition of (5); thus the sign of $\partial T/\partial m$ is determined by the sign of $\partial R/\partial m$. Also, (5) suggests that there will be a tendency for $|\partial T/\partial m|<1$ if $|\partial R/\partial m|$ is small relative to $|\partial R/\partial T|$. Note that we are using $\partial R/\partial m$ and $\partial R/\partial T$ to denote the partial derivatives of $R(u, v)$ at the point (m, T).

The sign of $\partial R/\partial m$ has already been established as negative because of the physical relations involved in pasture and range renewal. Therefore, *any stable equilibrium is of the oscillatory type.* The condition that $\partial R/\partial m$ be small relative to $\partial R/\partial T$ in pasture renewal implies that the immediate effect of encroaching brush and timber dominates the lagged effect of the previous stand of brush and timber. Certainly this seems plausible, and we would also expect $\partial R/\partial m$ to be near zero at $v=T$ if the lagged effect dissipates itself within one renewal period.

Differentiation of (3) with respect to m, treating T as implicitly a function of m, and assuming the second-order condition given by (5) is met, $f'(m)$ is negative since $\partial R(m, T)/\partial m<0$. Typically one would expect $c'(T)>0$. Thus the two terms in the denominator of (6) that contain the interest rate, i, are positive and increase in magnitude with respect to i. Therefore high interest rates will tend to decrease the absolute value of the denominator in (6) and constitute a force toward instability. Also, a sufficiently high interest rate would prevent relation (5) from holding.

An Asymptotic Decision Rule

As an approximately optimal decision rule we consider moving directly to the equilibrium associated with the optimal policy instead of moving toward that equilibrium by following the optimal policy. In other words, let us look at a policy that skips the transition to equilibrium and jumps the process immediately to that equilibrium. This view of the decision problem allows it to be stated in a form amenable to the calculus, and only one variable must be determined—optimal cycle length in equilibrium. The results are only of a quasi-dynamic nature, analogous to economic growth models that look only at the optimal growth path for the nation once the path is reached, without consideration of how to optimally reach that path.

Present value of quasi-rents from the pasture or range under a constant renewal cycle can be written as

$$V(m,T)=\int_0^T e^{-ix}R(m,x)dx-e^{-iT}c(T)+\frac{e^{-iT}}{1-e^{-iT}}\left[\int_0^T e^{-ix}R(T,x)dx-e^{-iT}c(T)\right], \tag{7}$$

where m is length of the immediately com-

pleted cycle and T is the cycle length to be maintained perpetually. Differentiation of (7) with respect to T, setting the derivative equal to zero and setting $m=T$, yields

$$R(T, T) + ic(T) - c'(T) + \int_0^T \frac{\partial R(T, x)}{\partial T} e^{-ix}dx = \frac{i}{1-e^{-iT}}\left[\int_0^T e^{-ix}R(T, x)dx - e^{-iT}c(T)\right]. \tag{8}$$

Setting $m=T$ puts the initial state of the process at equilibrium. In finding the necessary conditions for equilibrium the initial state must be taken as given, and the necessary conditions for maximum present value under a fixed renewal cycle are then derived. These necessary conditions are applicable for any initial state m; so when m is set equal to the implied renewal cycle, the resulting equation implies the equilibrium cycle. Putting $m=T$ in (7) before differentiation to get the counterpart of (8) would give erroneous results. Relation (8) defines T for the equilibrium to which the decision process converges when following the decision rule implied by the functional equation of the dynamic programming model—equation (2) or equations (3) and (4).

An economic interpretation of the individual terms in (8) shows the equation to be a marginal condition with considerable intuitive appeal. The first term, $R(T, T)$, is marginal immediate net returns; $ic(T)$ is interest on renewal costs; $c'(T)$ is marginal renewal costs; the integral on the left side of the equation is discounted marginal lagged effects on net returns from a complete production cycle; and the right hand side of the equation is amortized present value of the pasture operated under the optimal renewal period. The left hand side of (8) is marginal net returns associated with an increment to the renewal period, T, while the right hand side is the marginal net returns associated with immediate renewal. Direct application of (8) to determine the renewal cycle moves the decision process from any initial state directly to the equilibrium that would be approached asymptotically under an optimal policy.

As far as an approximately optimal policy is concerned, direct maximization of (7) for a given initial state m is preferable to solving for T in equation (8). Denote the solution of (8) by T^* which is the asymptotic cycle under an optimal policy. Unless the initial state is equal to T^*, choosing T to maximize (7) will provide a better policy than T^* since

$$\max_T V(m, T) \geq V(m, T^*).$$

Since only integer values of T are meaningful, a practical means of solution would be to merely tabulate $V(m, T)$ for various values of T, i.e., a direct search for the maximum. However, the necessary conditions for $V(m, T)$ a maximum for any given value of m, not necessarily equal to T, are

$$R(m, T) - e^{-iT}[R(m, T) - R(T, T)] + ic(T) - c'(T) + \int_0^T \frac{\partial R(T, x)}{\partial T} e^{-ix}dx = \frac{i}{1-e^{-iT}}\left[\int_0^T e^{-ix}R(T, x)dx - e^{-iT}c(T)\right]. \tag{9}$$

In the event that continuous functions are used in an application, solution of (9) in the variable T for given values of m yields an approximately optimal decision rule. The magnitude of m is a predetermined variable at any point in the decision process.

It should be kept in mind that the maximizing value of T for given m, determined for all m, constitutes the approximately optimal decision rule. The same renewal cycle is not repeated except when m turns out to equal the maximizing value of T. The specified constant renewal cycle is merely a means to an end, i.e., derivation of an approximately optimal decision rule. Of course, it also provides a convenient way to find the equilibrium renewal cycle as well.

If a rancher has several tracts of land that had different length renewal cycles previously, i.e., m is not the same for each tract, and the time elapsed since the last renewal is different from tract to tract, one might ask which tract should be renewed this year or which tract should be renewed first. Assuming that the discount rate, i, is in fact an exogenously determined opportunity cost of capital, either of these questions is answered by the optimal decision rule that specified an optimal T for each value of m, say $T(m)$.

It is assumed that the various tracts are of

homogeneous productivity. Let v_j be the time since renewal for the jth tract and let m_j be length of the last renewal cycle. If $v_j \geq T(m_j)$, the tract is renewed; otherwise, the rancher waits $T(m_j) - v_j$ more years before renewal.

If the discount rate, i, is not determined exogenously from the renewal policy, the present value criterion loses its validity. Under some quite specific assumptions (see [6, pp. 338–41]) the internal rate of return is applicable. The assumptions and arguments in [6] must be generalized considerably to fit the present more complex problem.

Higher-Order Dependence Structures

Let us now briefly examine the implications of a higher-order dependence structure among renewal cycles with respect to the quasi-rent functions. A second-order dependence would imply an additional argument in the quasi-rent function, $R(m_2, m_1, v)$, where m_1 is length of the last renewal period and m_2 is length of the renewal period before that, while v is the number of years since a renewal. The new variable is m_2, and m_1 is the same as m in the first-order relation.

The dynamic programming functional equation comparable to (2) is

$$f(m_2, m_1) = \underset{T}{\text{Max}} \left[\int_0^T e^{-ix} R(m_2, m_1, x)\,dx - e^{-iT} c(T) + e^{-iT} f(m_1, T) \right]. \tag{10}$$

The transformations of state variables in going from the left-hand side of (10) to the right are $m_2 \rightarrow m_1$ and $m_1 \rightarrow T$. The model and method of solution are essentially the same as before, but the burden of numerical solution is much greater [3].

If the dependence structure is too complicated to be handled by a second-order dependence model, there is an alternative formulation that requires only one state variable. Of course, it could also be used for the simpler first- and second-order cases as well, but the empirical measures required might be more difficult to estimate.

The single-state variable that replaces m_1, m_2, as well as additional renewal cycles if relevant, is an index of current range conditions. This index could be as simple a measure as the percent of land area covered by productive vegetation (or its inverse—percent of area not covered by productive species). The main influence of encroaching brush and timber that takes considerable time to dissipate is its smothering effect on the forage species. Without reseeding in a prepared seedbed, the forage plants must spread over the empty space left after removal of the brush and scrub timber. Reseeding with minimal or no seedbed preparation only expedites the recovery process, as would fertilization.

One of the most difficult empirical measurement problems is to obtain an estimate of the transformation function associated with the range index used as a state variable. Let the index be denoted by y, while the time since a renewal has been made is still denoted by v. Conceptually there exists a transformation function, say $\psi(y, v)$, which is the index associated with the following renewal cycle when y and v are the variables with respect to the current cycle. If we had an estimate of the transformation function and the quasi-rent function, $R(y, v)$, the dynamic programming functional equation would be

$$f(y) = \underset{T}{\text{Max}} \left[\int_0^T e^{-ix} R(y, x)\,dx - e^{-iT} c(T) + e^{-iT} f(\psi(y, T)) \right], \tag{11}$$

which could be easily solved by numerical methods.

If there is significant stochastic variation in the transformation of the state variable from stage to stage, an estimate of the probability distribution would permit a stochastic version of the functional equation in (11) where $f(\psi(y, T))$ is prefixed with the expectation operator. Numerical solution could be achieved by approximating the continuous variable model in a discrete Markov chain dynamic programming model such as that used by the author in [7, 8].

Conceptually at least, there is no difficulty in defining the state variable, y, as a vector that would permit more accurate description of the state of the process and thus use additional information to attain a more nearly optimal decision rule. However, numerical solution would become difficult if the vector y were to contain more than two components.

A generalization of the model to permit the quasi-rent function to reflect additional decision variables of a dynamic character would involve the calculus of variations. Introduction of stock-

ing rates into the model as a variable is an example, since quasi-rents would be a function of the stocking rate and its first derivative with respect to time. One could reformulate the dynamic programming model with the stage defined by a fixed time period instead of the renewal cycle and accommodate this generalized problem, but it would require an additional state variable that would measure stocking rate.

An Illustrative Example

This example is based on data from [9] for pinyon-juniper control in Arizona. One can hardly call it an empirical application because certain data that were not available, but required to estimate a production function, were largely fabricated. Except for these few data points, the example is an application to pinyon-juniper control. Even if these data points were experimental observations, the total number of data points would be so few that the results could be considered only suggestive.

The production function for forage is denoted $Q(u, v)$, where u is length of the preceding renewal cycle and v is time since the last renewal. Data from Cotner [9] were used as a source of data points to estimate $Q(u, v)$ but some adjustments and interpretation were required. It was assumed that the data in his Table 2 [9, p. 735] implied a condition in which new growth pinyon-juniper was continuously removed to allow the forage to reach its maximum potential productivity. It was also assumed that the previous renewal cycle was relatively long, 78 years to be exact. To adjust those data to correspond to a situation in which new growth was not continuously removed after control, it was assumed that production was as given in Cotner's Table 2 until 8 years after control but declined thereafter in relation to the percentages given in his Table 1 [9, p. 734].

The initial yield in Cotner's Table 1 is supposedly maximum potential yield after continuous control of new growth pinyon-juniper during the recovery period. We arbitrarily took the yields given in that table as $Q(0, v)$, $v=0$, 13, 26, . . . 78. The final set of data points is given in Table 1 of this paper for Cotner's medium potential site. Only two levels are available for the first variable, u, which makes any equation fitted to the data very crude with respect to the influence of that variable.

The following algebraic equation was fitted to the data of Table 1 by nonlinear least squares:

Table 1. Data points used to fit $Q(u, v)$

Previous renewal cycle, u	Time since renewal, v	Production (lbs. forage) $Q(u, v)$
0	0	464
0	13	436
0	26	310
0	39	186
0	52	135
0	65	116
0	78	97[a]
78	2	116
78	4	227
78	6	348
78	8	404
78	13	380
78	26	271
78	39	162
78	52	117
78	65	101
78	78	85

[a] Printed as 87 in [9, p. 734], but apparently a misprint when compared to the percentage of potential yield.

$$(12) \quad Q(u, v) = b_1 + b_2[e^{-b_3u-b_4v} - b_7e^{b_5u-b_6v}].$$

The seven parameters are assumed positive, which gives the function $Q(u, v)$ its desired properties on a priori grounds. First, $\partial Q/\partial u<0$ for all positive values of u and v; also, $\partial Q/\partial v$ is positive over part of its range and negative over part of it. The positive range of $\partial Q/\partial v$ is the recovery period after control, while the negative range is the encroachment period after maximum production has been reached. This production function has an asymptotic yield equal to b_1, with respect to v, for any finite value of the first argument, u. The fitted relation gave the parameter estimates in Table 2.

In this limited experience of using (12) as an algebraic form to approximate forage yield, its main defect appeared to be in the interval on v near zero when the concomitant value of u is relatively large. In particular, the function is

Table 2. Fitted production function

Parameter	Least squares estimate	Approximate standard error
b_1	68	18
b_2	[illegible]725	89
b_3	.00112	.00093
b_4	.04576	.0078
b_5	.01276	.0030
b_6	.22416	.040
b_7	.45441	.089

Standard error of the estimate: 17.6
Coefficient of multiple determination: .989
Degrees of freedom: 10

Table 3. Renewal cost data

Years since renewal	5	10	20	30	40	50	60	70	80
Cost (dollars per acre)	0.26	0.28	0.36	0.97	1.49	2.20	2.25	2.34	2.47

negative on part of the interval, zero to unity, if u is greater than about 60. Introduction of an artificial data point with $v=0$ and $u=78$ caused a poor fit by nonlinear least squares to the entire data set. It was concluded that equation (12) is not an acceptable approximation to the production function within one or two units of zero in the second argument, v, when the first argument, u, is relatively large.

This limitation of (12) as an empirical production function is not serious, since quasi-rents will usually be zero during the renewal activity; and if deferred grazing is practiced to speed the recovery process, quasi-rents will be zero for another year or two after renewal. Therefore, the integrals involving the quasi-rents would merely have a lower limit greater than zero, two or three for example; and the production function would not be fitted to data points near zero in the second argument when the first argument is relatively large.

The following analysis of this illustrative example ignores the difficulty and integrates from zero. The resulting optimal policy implies renewal cycles of quite short duration, so no serious error is encountered, although it would be more realistic to assume some zero quasi-rents immediately after renewal.

Costs of renewal (pinyon-juniper control) were developed from Cotner's Table 3 [9, p. 737]. For a given age of stand, our variable v, it was assumed that the least-cost method would be used. This assumption implied hand chopping for $v=5, 10, 20, 30$; individual tree burning for $v=40$; and cabling for $v=50, 60, 70, 80$. Since cabling would not be comparable to other methods in completeness of control, an additional dollar per acre for supplementary hand chopping was added to costs of cabling. The resulting data points were those given in Table 3 above. The transition to cabling suggested a discontinuity in the cost function, so two separate quadratic equations were fitted, one each for v from 5 to 40 and 50 to 80. The two fitted equations were

$$(13) \quad c(v) = .30 - .01557v + .001153v^2 \qquad 0 \leq v \leq 45$$

$$(14) \quad c(v) = 2.55 - .01700v + .00020v^2 \qquad v > 45.$$

A forage value of 7 dollars per ton and an interest rate of 10 percent were assumed initially. Equation (2) was solved numerically for integer values of m and T from 5 to 75. The lower limit was imposed because the Markovian assumption could hardly hold for values of m less than 5 and the upper limit reflects the limit of the data set used. The decision rule is given in Table 4. Recall the conditional nature of the decision rule, an optimal T for each m, say $T(m)$.

Table 4. The optimal decision rule

Previous renewal cycle, m	5 to 8	9 to 13	14 to 16	17 to 75
Optimal current cycle, $T(m)$	9	8	7	5

From Table 4, it is apparent that a stable equilibrium exists between 8 and 9 years, since an equilbrium implies $T(m)=m$ and the equilibrium is approached from any initial position on the interval 5 to 75. However, the integer restriction in practice implies ultimate oscillation between 8 and 9 instead of an equilibrium. Solution of equation (8) confirmed the continuous variable equilibrium to be 8.485 years.

In order to illustrate the dynamic decision rule, assume an initial situation in which the last renewal cycle was 50 years and the time since that renewal is 25 years, i.e., $m=50$ and $v=25$. Since $v>T(m)$, the range is immediately renewed; in fact, it should have been done 20 years ago at $v=T(m)=5$ (see Table 4, last column). After the renewal, the decision process is in a new state, viz., $m=25$; and we see from Table 4 that the next renewal should be made in 5 years. After 5 years the renewal is made, and the new state is $m=5$. By Table 4, the next renewal should be in 9 years. From that renewal into perpetuity, the renewals oscillate between 8 and 9 years.

Some sensitivity analysis was performed by letting the interest rate range from 5 to 20 percent and the forage price range from 1 to 10

dollars per ton. At a forage price of 7 dollars per ton, the equilibrium was 7.82 and 9.88 years at interest rates of 5 and 20 percent, respectively. At an interest rate of 10 percent, the equilibrium was 12.62 and 8.15 years at forage prices of 1 and 10 dollars per ton, respectively. The equilibrium renewal cycle appears to be quite stable in this example with respect to either the interest rate or price of forage.

Nevertheless, a case was encountered in which an equilibrium was nonexistent, namely, at an interest rate of 20 percent and a forage price of 1 dollar per ton. Equation (8) had no solution and the solution of (2) yielded a policy as follows: $T(m)=75$, $m=5, 6, \cdots 64$, and $T(m)=5$, $m=65, 66, \cdots 75$. Thus, the optimal policy is to oscillate between the boundaries placed on the variables.

Sensitivity to costs was checked by doubling costs, which changed the equilibrium by less than one year.

The approximately optimal policy associated with maximization of $V(m,T)$ with respect to T for all values of m in equation (7) is presented in Table 5. Price of forage is 7 dollars per ton and the interest rate is 10 percent, so that Tables 4 and 5 can be compared. The policies are identical for $m=5, 6, \cdots 13$, and the remaining differences are trivial in their consequences on the criterion function.

Results of numerical problems can be only suggestive, but the results here certainly do not discourage using the approximately optimal policy. However, the computations on a digital computer are relatively simple for solution of equation (2), which may encourage derivation of the optimal policy. FORTRAN programs are available from the author to solve either problem.

Table 5. Approximately optimal policy

Previous renewal cycle, m	5 to 8	9 to 20	21 to 30	31 to 37	38 to 75
Approx. Optimal current cycle, $T(m)$	9	8	7	6	5

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Resource Investments, Impact Distribution, and Evaluation Concepts*

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Governmental decisions on proposed resource investments have always been made within an implicit multidimensional social welfare function framework. Yet the equity consequences of public programs have never been evaluated on an equal basis with their contribution to national economic growth. A model designed to facilitate the measurement of such consequences is specified and applied to a case study. The model can be used in conjunction with different equity classifications, but the test considered the personal income distribution consequences of a proposed water resource investment. The distribution of efficiency benefits and positive intergroup transfers as well as cost and reimbursement questions are considered.

EVALUATION of alternative proposals for governmental resource investment has normally not been carried out within a multiobjective framework. The single-valued objective function of national economic efficiency has been the mainstay of governmental analysis. Although Senate Document 97 gives official recognition to several other objectives, little effort has gone into perfecting the methodology necessary to obtain quantitative estimates of project effects on those objectives or of properly associating the results of such estimates with the planning process [31, pp. 16–25; 25]. Even though largely neglected by the economics profession, however, equity impacts[1] of public proposals have important implications for governmental decision making.[2] The political process can effectively utilize information on such impacts to point up and permit the resolution of decision-making bottlenecks. The result can be a smoother operating and more responsive public sector [6, p. 4].

To the extent that investment evaluation has utilized objectives other than national economic efficiency, regional development has been the primary concern [9, 15, 19]. In practice, this has led to a resurrection of the so-called secondary impact concept. Although the literature is replete with discussions of this notion [1, pp. 17–28; 2; 3, ch. 7; 5; 8; 14; 16, ch. 9; 28, pp. 8–10; 31], the term has always been conceptually ambiguous. It is widely used as a euphemism for impacts of water resource projects that are interregional transfers [19]. On the other hand, "changes in the production possibility surface of the private sector" resulting from resource investments are often referred to as secondary benefits [10]. Thus, no clear conceptual separation is provided between those effects properly considered under both national economic efficiency and distributional objectives and those of a purely distributional nature. By lumping impacts having a mixed character with respect to objectives under one classification, empirical analysis is inhibited and research results made less meaningful.

For example, evaluation of equity-distributional effects has concentrated on positive interregional transfers and the development of regional multipliers by which they can be measured. Little emphasis has been placed on questions relating to the incidence of the *various* national economic efficiency components[3] or to adverse transfers. All the appropriate components of the national efficiency impact plus the

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[1] In the study of welfare economics departures from the criterion of economic efficiency for program evaluation reduce to questions relating to the distribution of program impacts [12, p. 18; 32, p. 177]. Other issues, such as the classification of impact groups, the relevant distributional criteria, and the definition of impacts and their measurement, can all logically be placed under this framework. For example, the relevant group classification may involve regions, income groups, economic sectors, or other population segments, but all are merely different subdivisions for purposes of analyzing the distributional issue.

[2] In a broader context this applies to all public investment decisions, whether or not they are primarily for developmental purposes as defined by Leven [10], as well as to changes in public rules or institutions [21].

[3] Because transfer effects normally have not been and should not be recognized as a gain in real national income [25, pp. 5–6; 16, ch. 9; 3, ch. 7], program impacts from the national economic efficiency perspective are often said to include only the value of additional program output (valued in light of without project demand conditions) [10, 19]. However, the value of technological externalities and productivity changes caused by public investment, which are not merely transfers, should also be considered as a national effect even though they are less susceptible to quantification.

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relevant intergroup transfer effects on the classification under consideration, however, need to be considered. Conceptually, transfers are only one component of a project's distributional consequences, since all economic efficiency impacts have distributional implications.

Several points flow from this short review. First, more emphasis is needed on empirical methods of measuring productivity changes and technological externalities resulting from public investments, and of identifying regional gainers and losers from a more comprehensive perspective than mere interregional transfers. This would serve to place in its proper perspective the now conventional approach to distributional evaluation of measuring transfer (secondary) impacts through regional multiplier analysis, as exemplified by economic base studies, regional interindustry models, and simple Keynesian models. Second, although analysts have largely neglected distribution issues of all varieties, emphasis on regions and growth in regional income has resulted in the lack of analysis of project impacts to other income groups and economic sectors, both nationally and regionally. Without such information the question of which groups and sectors gain and which lose from program implementation and whether such impacts are commensurate with society's views on equity or with the impacts of other programs cannot be fully answered.

Finally, analysis of relevant distributional impacts raises issues beyond those of impact class definition or techniques to quantify appropriate project effects. Since any project-induced change involves distributional considerations, a framework for equity evaluation is needed. Such a framework needs to consider not only the distribution of efficiency benefits and positive intergroup transfers but also cost and reimbursement[4] questions for each distributional class. A potential framework for such an analysis is the principal topic of this paper. The model presented in the next section is general in nature in that it does not attempt to identify meaningful distributional classifications [32] and assumes that measurement techniques are available to quantify all appropriate project impacts. An example of the model's application to a proposed project follows as an illustration of data requirements and empirical problems.

An Equity Evaluation Framework

Income distribution is changed by federal resource investments whenever the distribution of project *net* benefits is nonproportional to the income distribution projected to occur without the project in question.[5] Net benefits generally consist of income in kind, in that provision of public goods at a price below willingness to pay releases private resources for other uses. In order to determine the magnitude of benefits and costs accruing to a distributional classification, the benefits received are defined as a portion of total project benefits.[6] The costs borne by each classification are defined to include a portion of the indirect payment, via taxation, of total investment and operating costs of the project, and any direct payments for benefits received.[7] Then the total cost can be netted against total benefits for each classification, and the resulting net benefit distribution can be compared to a reference income distribution.

If the benefits to a distributional class accrue to that classification in the absence of reimbursement, the conceptual model is similar to that used for a national economic efficiency analysis. Therefore, the following formulation can be utilized:

[4] The term "reimbursement" refers to the partial or total repayment of project costs or, alternatively, payment for benefits received as a result of a project. In effect, reimbursements are also transfers, but they have not been adequately considered in most equity evaluations.

[5] Schmid has suggested that redistribution occurs whenever the distribution of *gross* benefits is nonproportional to the distribution of project costs [21]. This ignores, however, the fact that costs may not be distributed in proportion to reference income or assumes that society's interest in equity corresponds to the benefit principle of taxation. Schmid's formulation eliminates the need to define a reference distribution but provides little basis by which alternatives can be compared. The formulation suggested above assumes that an appropriate reference base can be defined which would be of assistance to public decision makers in comparing alternative projects and programs.

[6] For example, if the analysis takes a national viewpoint, total project benefits would correspond to national efficiency benefits. A regional analysis, however, would consider the total regional benefit of a project, including the appropriate positive transfers and national costs that benefit the region.

[7] If the *relative* impact of a project on income distribution is of major concern, reimbursement is not a complicating factor and the budget constraint is fixed, the cost side of the distribution account will be fixed and will not affect the net. Thus, only the distribution of benefits is required. If, however, the *absolute* impacts are of concern, reimbursement is required, and/or the budget constraint is flexible and depends on project evaluation, the cost side of the account must be quantified.

$$\text{Net Benefit}_a = \sum_{t=1}^{T} \frac{B_{at}}{(1+i)^t} - \left[Z_a + \sum_{t=1}^{T} \frac{O_{at}}{(1+i)^t}\right] \tag{1}$$

It is assumed that distributional classifications will not be indifferent to the timing of benefit impacts. Therefore, because benefits and costs accrue to various classifications over time, a discounting procedure is necessary to place them on a present value basis. The present value of benefits to class a is represented by the first component of equation (1). Thus, B_{at} represents the annual dollar benefit to the class, i the discount rate, and T the time horizon. The value representing benefits per unit of time can be looked upon as incorporating all relevant benefits to the distributional class under consideration. Thus, both national economic efficiency benefits, including primary impacts, externalities, and productivity effects, and the appropriate transfers would be included in this value. The second part of equation (1) specifies the total present value cost of a project to class a where Z_a represents the portion of the tax payment by class a that is allocated to the construction of the project and O_{at} represents annual operating, maintenance, and repair costs to class a. Taken as a whole, then, equation (1) represents the present value of the net benefit accruing to class a.

If reimbursement is a requirement of the project for all or a portion of its costs, however, the analysis is altered although the basic conceptual framework remains intact. Reimbursement procedures will usually have inherent distribution effects. For example, a portion of a project's investment cost may be allocated to its water supply function. Localities receiving the water supply are required, by statute, to repay over time the allocated cost of water supply. The effect of such a reimbursement procedure upon distributional groups can be seen in Table 1.

Table 1. Example of reimbursement distribution effect

Distributional class (j)[d]	Z[a]	B[b]	R[c]
c	10	20	30
d	20	30	20
e	30	20	10

[a] Z = tax revenue used to finance the water supply function by the federal government.
[b] B = benefits.
[c] R = reimbursement.
[d] J = distributional classes ($j = c, d, e$).

Table 1 assumes that class c pays 10 in taxes to finance the water supply component of the project and through consumption receives 20 in benefits (income in kind). However, federal law requires that the total investment cost of water supply (assume that all figures are on a present value basis) be repaid to the federal government by the locality receiving the supply.[8] The *initial* effect on class c is that it pays 10 in taxes and receives a benefit of 20 or a positive net benefit of 10. Assume, however, that when reimbursement is taken into consideration, the *final* effect is that class c pays 30 and receives a benefit of 20. For class c the income distribution effect changes from $+10$ to -10 because of reimbursement.[9]

If reimbursement was 100 percent and proportional to the taxes paid, distributional class c would reimburse 10/60 of total reimbursement, or 10. Proportional reimbursement may be represented as

$$P_c = \left| K_c \sum_{t=1}^{T} \frac{\left(\sum_{j=c}^{e} R_{jt}\right)}{(1+i)^t} \right| \tag{2}$$

where K_c is the proportion of the total tax paid by group c. The remainder of the expression is the present value of the total reimbursement, or 60 in the example. The proportion K_c multiplied by the present value of the total reimbursement is the amount of reimbursement that would be paid by class c if reimbursement were proportional to the appropriate tax structure.[10]

The *actual* present value of the reimbursement paid by class c may be written as

$$A_c = \sum_{t=1}^{T} \frac{R_{ct}}{(1+i)^t} \tag{3}$$

[8] The example and subsequent formulation assumes that annual operating and maintenance costs will either be paid *directly* by the project beneficiaries or will be nonreimbursable. In any case the analysis would be the same.

[9] The reimbursement figure does not include the original taxes of 10 because it is assumed that the 60 in taxes for the project was a loan by society to itself and that loan is being repaid. Therefore, although the federal tax cost to society as a whole is zero, the distribution impact is dependent on the nature of reimbursement.

[10] Note that reimbursement does not need to be 100 percent for this expression to hold.

The difference between the actual reimbursement and proportional reimbursement may be titled the "reimbursement adjustment." It is measured as a positive or negative deviation from the tax structure. The investment cost for a distributional group, therefore, consists of the initial tax plus the reimbursement adjustment. The total cost to group c is expressed by the actual investment cost plus the present value of operating and maintenance costs accruing to it. Therefore, the net benefit[11] of *any* distributional group, j, is expressed as:

$$\text{Net Benefit}_j = \sum_{t=1}^{T} \frac{B_{jt}}{(1+i)^t} - \left[Z_j + \left\{ \sum_{t=1}^{T} \frac{R_{jt}}{(1+i)^t} - K_j \left[\sum_{t=1}^{T} \frac{\left(\sum_{j=1}^{J} R_{jt} \right)}{(1+i)^t} \right] \right\} + \sum_{t=1}^{T} \frac{0_{jt}}{(1+i)^t} \right] \quad (4)$$

where $j = 1,2,3, \cdots, J$.

Implementation of the formulation for all distributional classes in the model permits calculation of both the absolute and relative distribution of net present value benefits to the classes. The relative distribution of project net benefits can then be compared with the expected distribution of income without the project to ascertain whether the project will cause an alteration in that situation.[12]

The model presented contains several simplifying assumptions for purposes of exposition. First, it assumes that the round-by-round impacts on the economy of an initial change in distribution caused by a project are of no consequence. However, the final effect of an initial change in distribution will probably differ from the initial impact measured by the model. For example, assume that an initial change in income distribution is caused by the project so that group B gains relative to group A. The expenditure patterns of group A may differ from those of group B. When group A spends any resources released because of the project, there will be other distributional effects due to that expenditure. Similarly, group B contracts expenditures, and this is felt throughout the economy. Although the model can be implemented without considering such impacts, it must be recognized that they *may* be of importance and cannot be passed off as pecuniary effects as in an economic efficiency analysis.

Second, the composition of distributional classes may change over time because of external factors; therefore, the demand by any one class for a project's output may be expected to change. Hence, the quantity consumed will be altered; and this in turn results in an altered distributional effect. Methods of handling this problem must be explored.

Finally, the actual allocation of project costs and benefits to distributional classes presents numerous empirical problems. Such allocations must, by necessity, proceed along the functional lines of the project. This is necessary because benefits arising from various functions may be distributed differently to distributional classes. Also, cost distributions can change because of reimbursement policy. Therefore, the

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[11] If the assumption of equal marginal utility of income for all individuals or groups is considered too restrictive and if welfare equivalent weights (θj's) are available, the results of the formulation can be multiplied by the appropriate constant to obtain an improved measure of welfare change. It has been suggested that measures of income utility to different classes could be deduced from "the effective marginal rates of the personal income tax at different income levels" [4, pp. 133–34]. Such an approach uses, of course, "governmentally imposed" utilities to measure satisfaction from government expenditure.

[12] It should be noted that the income distribution effects of public investments can vary depending upon the region defined for quantification of such impacts. The model outlined above was formulated from the national point of view. To use it in a regional context, reimbursement would need to be zero or a modification of equation (4) would be needed. Such a need stems from the normal reimbursement situation in which a local or regional unit of government is required to repay to the federal government all or part of total federal costs rather than just the regional share of federal taxes devoted to a project. Thus, Z_j in equation (4), which in the regional context would denote the regional portion of federal taxes paid by income class j, would give the improper value against which the "reimbursement adjustment" should be applied. The value that should be substituted for Z_j in equation (4) can be represented by

$$Z_{j\lambda} = \alpha_{j\lambda}(\gamma Z_{jn}) + \phi Z_{jn} \quad (5)$$

where, Z_{jn} represents total federal investment cost distributed nationally to distributional classes in proportion to total federal taxes paid; $\alpha_{j\lambda}$ represents the percent of federal tax revenue paid by class j and raised in the region; γ represents the percent of nonreimbursable federal tax cost; and ϕ represents the percent of reimbursable federal tax cost. $Z_{j\lambda}$, then, represents the present value investment cost of the project borne by the regional component of class j if that cost is distributed in proportion to the federal tax structure. In other words, Z_λ is the total cost, due to both taxes and reimbursement (but without double counting), of a project to a region. The formula assumes that reimbursement will not exceed federal tax cost on a present value basis.

estimation of a project's equity impact is dependent on the method of allocation used for joint project costs (when they exist *and* when nonproportional reimbursement occurs).[13] The principal problem, in addition to the issues raised above, in allocating costs and benefits to the various distributional classes is the lack of available data by which such allocations can be made.

Thus, the model posed serves to point out the issues that have policy implications and need further research effort. First, it is clear that empirical implementation would be difficult. Little previous attention has been paid to the distribution of national economic efficiency benefits to various classes, however defined. This deficiency is important not only because of the distributional effect of such benefits but because their magnitude and incidence serve as the origin of additional transfer or multiplier impacts. Second, the model clearly points up the fact that cost sharing and reimbursement arrangements are an important means of affecting the distribution of project impacts. Not only must they be considered in the evaluation of such impacts, but they appear to be a potentially important policy tool for use by decision makers. In essence, they provide another alternative in project formulation. However, the inflexibility of current reimbursement formulas makes their utilization difficult in such a context.

Model Implementation

To illustrate empirical difficulties and to explore potential data sources, the equity model was utilized to evaluate the personal income distribution aspect of the proposed multipurpose Stonewall Jackson Reservoir in West Virginia [26]. The original economic evaluation of that proposal [24] was revised by using a $4\frac{7}{8}$ percent rather than the original $3\frac{1}{4}$ percent discount rate, and by following recently proposed guidelines [31] for estimation of efficiency benefits (see [7, pp. 8–32]). Upon reevaluation the proposal produced a 0.75 benefit-cost ratio on $35,936,000 of initial investment.

The equity model was implemented for a region surrounding the actual project site and associated downstream locations, defined by zip code areas 263 and 264. The advantage of such a definition was that all flood control and water supply benefits of the project and a majority of the recreation impacts accrue to this region. Moreover, in view of the local impact of reimbursement requirements, the absolute bulk of any distributional impact will fall in such a region. Any change in relative impact caused by taking a national rather than regional perspective would be small. Zip code areas were used to define regional lines because of available data on the present distribution of income.

Reference distribution

Adjusted gross income for 1966 as obtained from the region's federal tax returns [30] was utilized to define the present distribution of personal income.[14] This classification was used as the reference point for the study. Data limitations permitted only three income classes to be defined (Table 2).

Table 2. Reference income distribution for zip code area 263–264

Class	Percent of population in class	Percent of adjusted gross income in class
Less than $3,000	26	11
$3,000–$10,000	63	62
Over $10,000	11	27

Source: [30].

Benefit-cost allocation

As indicated, to determine the net present value of distributional effects by classes, the project's benefits and costs must be allocated to each of its primary functions. Table 3 shows the results of this allocation as determined by using the separable cost-remaining benefit al-

[13] Analytical results should not be affected by this fact as long as evaluation is consistent with and utilizes the same approach as that used for *actual* allocation of joint costs. Thus, because actual reimbursement requirements are based on the "separable cost-remaining benefit" method and because only reimbursement will alter the allocation of costs to distributional groups, the method of joint cost allocation should not affect analytical results if the model utilizes the same approach for joint cost allocation.

[14] Since the analysis was carried out using *household* income as the income base, it was assumed that the tax returns represented household income. However, such an estimate has a downward bias because of the use of separate returns within households. Data to make the necessary adjustments or improved sources of information were not available.

Table 3. Benefits and costs by project function—Stonewall Jackson Reservoir

Function	Average annual benefit	Investment cost	Average annual operating and maintenance cost[a]
	dollars		
Flood control	765,000	29,108,200	69,300
Water supply	191,900	1,796,800	−7,600
Recreation	479,000	5,521,000	102,000

[a] Negative costs arise from the nature of the separable cost-remaining benefit method when used with an economically inefficient project. In essence, one function is subsidizing another.

Table 4. Allocation of federal tax to national income groups, 1966

Class	Average federal tax per family[a]	Households in nation	Total tax in nation	Percent of federal tax paid by income class
	(1)	(2)	(3)	(4)
	dollars			*percent*
Less than $3,000	264	11,293,320	2,981,436,480	2
$3,000–$10,000	1,317	32,717,160	43,088,499,720	33
Over $10,000	5,637	14,951,310	84,280,534,470	65

[a] Average federal tax per family excludes social insurance since it is not part of revenue from which investment funds are drawn.
Source: Column (1): [23, Tables B-8 and B-9, pp. 47–48]. Column (2): [30, *Zip code area data*, 1]. Total exemptions in each income class divided by 3.29 people per household. Assumes that household and family definitions are identical.

location procedure (see footnote 13) and revised cost estimates [7]. Subsequent present value calculations utilized the currently defined government discount rate of $4\frac{5}{8}$ percent and a 100-year time horizon, except for the reimbursement portion of equation (4) where the time horizon was shortened to 50 years in accordance with the appropriate statutes [20].

Investment costs by income class.—The regional orientation of the study required the investment costs of each function to be allocated to the various income classes in accordance with equation (5). Since the federal tax costs, Z_N, of each function (or more generally of the total project) are raised from general federal revenues, they can be allocated to national income classes on the basis of an allocation of federal taxes to income classes. A recent allocation of the federal tax burden by income classes, published by the Tax Foundation in 1967, was utilized for this purpose [23]. The percentage of federal taxes allocated to the income groups defined for this study is presented in Table 4.[15]

The investment cost of each project function assigned to each income class was determined by multiplying the percentages from Table 4 by the appropriate investment costs. This calculation resulted in the distribution of *total* investment cost (Z_N). However, it is the distribution of regional costs that is desired, so the portion of total investment cost borne by the region must be determined (Table 5). For flood control, ϕ in equation (5) is equal to zero and therefore γ is equal to 100 percent. Thus, if $\alpha_{J\lambda}$ is known, the investment cost borne by each income class in the region ($Z_{J\lambda}$) for flood control can be derived. The $\alpha_{J\lambda}$ values were determined by calculating the amount of total federal income taxes paid by the respective regional income classes as a percent of total federal income taxes paid by the corresponding national classes.[16]

Table 5. Allocation of investment costs by function and income class

Class	Function	Investment cost borne by nation (Z_{JN})	Investment cost borne by region ($Z_{J\lambda}$)
		dollars	
Less than $3,000	Flood control	582,164	408
$3,000–$10,000		9,605,706	6,724
Over $10,000		18,920,330	5,676
Less than $3,000	Water supply	35,936	35,936
$3,000–$10,000		592,944	592,944
Over $10,000		1,167,920	1,167,920
Less than $3,000	Recreation	110,420	28,357
$3,000–$10,000		1,821,930	467,898
Over $10,000		3,588,650	920,551

Source: Tables 3 and 4.

Although the investment costs for water supply are initially paid from federal revenue,

[15] Several problems arise from the use of this procedure. For example, the income base is defined differently in the Tax Foundation study than by the data utilized in this study [30]. However, the difference was not expected to substantially bias the quantitative results. Another problem is that the average federal tax per family in Table 4 is based on 1960 data while the numbers of households in the nation are based on 1966 data. Therefore, it was assumed that the tax structure was unchanged from 1960 to 1966.

[16] The percentages were .07 percent, .07 percent, and .03 percent for the under $3,000, $3,000–10,000, and over $10,000 classes, respectively [26].

the Federal Water Supply Act stipulates that 100 percent of the total investment cost must be repaid to the Federal Government with interest at 4⅞ percent on the unpaid balance over a 50-year period. Therefore, ϕ is equal to 100 percent and $Z_{J\lambda}$ is equal to the investment cost for the function times the percent of federal taxes paid by the appropriate national income class (Table 4). This provides the cost of investment to the regional income classes when reimbursement is proportional to the federal tax structure.

The Federal Recreation Act stipulated that 50 percent of the *separable investment cost* of recreation be repaid to the Federal Government with interest at 4⅞ percent on the unpaid balance over a 50-year period. Thus, ϕ is equal to 25.6 percent and γ to 74.4 percent based on separable costs of $1,415,000 and total costs of $5,521,000. Using the appropriate Z_{JN} and $\alpha_{J\lambda}$ values gave the results shown in Table 5.

Benefits and annual costs by income class.— Data concerning the distribution of flood control benefits of the project to income classes were nonexistent. Therefore, it was assumed that flood control benefits would accrue to income groups in proportion to the initial income distribution of the region. The flood control benefits forecast from the project are $15,558,598 on a present value basis. The costs associated with flood control consist of allocated investment costs and allocated operation and maintenance costs. The present value of annual operation and maintenance costs is $1,409,423, and the appropriate portions were distributed to income groups in the region on the same basis as investment costs. The overall income distribution effect of the flood control function is presented in Table 6.

Table 6. Distribution of net benefits from flood control by regional income classes

Class	Benefits	Investment cost	Operation and maintenance	Present value net benefits
	dollars			
Less than $3,000	4,045,235	408	20	4,044,807
$3,000–$10,000	9,801,917	6,724	326	9,794,867
Over $10,000	1,711,446	5,676	275	1,705,495

Water supply benefits were distributed to income classes on the basis of water expenditure by income class as a proxy for the amount of water used by each class. The calculations are shown in Table 7. It was assumed that the required 100 percent repayment would be financed by the locality through water charges and that the repayment would be in equal amounts over the entire 50-year period. The annual repayment, with interest on the unpaid balance, is approximately $97,000 per year. This amount was distributed on the basis of the percent of average water expenditures incurred by each income class. In other words, the actual reimbursement cost was distributed to regional income classes in the same manner in which benefits were distributed. Operation and maintenance costs are by law paid by the locality, so it was also assumed that these costs would be borne by regional income classes according to their water expenditures. The results of the calculations using these assumptions and the distribution of the present value of net benefits is presented in Table 8.

Table 7. Distribution of water supply expenditures and benefits by income class

Class	Average water expenditures per household	Households in region	Total water expenditures	Percent water expenditure	Present value of benefit to income class[a]
	dollars	*number*	*dollars*	*percent*	*dollars*
Less than $3,000	7.5	9,775	73,313	11	429,315
$3,000–$10,000	17.1	23,484	401,576	62	2,419,776
Over $10,000	40.0	4,256	170,240	26	1,014,745

[a] Based on $3,902,864 of present value water supply benefits.
Source: [27].

Recreation benefits were distributed to income classes on the basis of the percentage of visitors to federal reservoirs by income classes in 1960. However, only a portion of these benefits accrue to those people who live in the region. It was assumed that this proportion was 50 percent.[17] Recreation costs involve all three cost components. The distribution of the regional investment costs to income classes was given in Table 5. Assuming repayment is in equal installments over the entire time horizon, the annual amount to be repaid is $77,000. The law stipulates that the source of repayment must be limited to entrance and user fees collected at the project. (It is also possible to have repayment in the form of lands, but this possibility was ignored.) Therefore, the $77,000 was distributed to income classes on the basis of reservoir use by income classes.

[17] This figure was based upon an estimate made by the Pittsburgh District Office of the Army Corps of Engineers.

Table 8. Distribution of net benefits from water supply by regional income class

Class	Gross benefit	Investment cost	Reimbursement adjustment[a]	Operation cost	Present value of net benefits
			dollars		
Less than $3,000	429,315	35,936	+162,507	−17,003	247,875
$3,000–$10,000	2,419,776	592,944	+523,642	−95,835	1,399,025
Over $10,000	1,014,745	1,167,920	−704,204	−40,189	591,218

[a] Does not add to zero due to rounding.

Table 9. Distribution of net benefits from recreation by regional income class

Class	Benefit[a]	Investment cost	Reimbursement adjustment	Operating costs	Present value net benefits
			dollars		
Less than $3,000	365,322	28,357	+78,837	77,793	180,335
$3,000–$10,000	3,497,349	467,898	+556,147	744,740	1,728,564
Over $10,000	1,008,288	920,551	−634,974	214,709	508,002

[a] Based on 7.5 percent, 71.8 percent and 20.7 percent of visitors for the under $3,000, $3,000–10,000, and over $10,000 classes, respectively [29]; and $9,741,919 of present value recreation benefits.

Operation and maintenance costs are paid entirely by user fees, so these costs are also allocated on the basis of reservoir use by income class. However, because only 50 percent of total visitation was of a regional origin, only 50 percent of these costs were included in the calculations. The net benefit distribution effect of the recreation function is presented in Table 9.

Summary

The total net benefit distribution of the Stonewall Jackson project is presented in Table 10. The project has a positive effect on all income classes in the defined region because the region is not required, through either taxes or reimbursement, to pay even a major share of project costs. This is true even though the project from the national efficiency viewpoint is inefficient. The relative distribution of benefits tends to favor the middle income group with 64 percent of the total, but the upper income class receives the largest absolute value per household at $659 of *present value* impacts. Conversely, the lower income group receives the lowest absolute value per household. Table 10 also compares the relative distribution of income in the region before the project with the regional distribution of project benefits. The project would result in a slight distribution effect in favor of the lower income group. The results are of course valid only for the specific region defined and under the assumptions outlined.

Conclusion

For resource planning, acceptance of the proposition that governmental decisions are made within the framework of a multidimensional social welfare function implies that the distributional consequences of public programs are issues on a par with contributions to national economic growth. The thrust of this paper has been to reemphasize that evaluation of proposed governmental decisions should be carried out within such a framework. This position is based upon the value judgment that

Table 10. Net benefit distribution and income distribution effect of the Stonewall Jackson project by regional income class

Class	Percent of adjusted gross income in class	Present value of net benefit	Percent of net benefits by income class	Net benefits per household[a]
	percent	*dollars*	*percent*	*dollars*
Less than $3,000	10	4,473,017	22	458
$3,000–$10,000	62	12,922,456	64	550
Over $10,000	27	2,804,715	14	659
Total		20,200,188	100	

[a] Households in the region number 9,775; 23,484; and 4,256 for the respective income classes.
Source: Tables 2, 6, 8, 9, and [30].

single-objective optimization exercises do not logically lead to welfare maximization. However, a multiobjective evaluation framework, although superior in design, requires clear conceptual separation of its component parts for purposes of measurement. A model designed to facilitate the measurement of often neglected equity consequences was set forth. A case study was then utilized to test the relevance of the model to empirical situations. That test pointed up the numerous empirical difficulties involved and the need for improved data on equity impacts.

The model postulated can be used to provide information on a number of different equity classifications. However, the appropriate number of dimensions to the social welfare function ultimately must be decided by the political process. Similarly, it is evident that *final* decisions on alternative courses of public action will not be made in terms of economic analysis. The results of evaluation done by economists will only serve as components in an overall decision-making framework. The trade-offs among such components are value judgments that must be defined externally. Whether or not a priori trade-off weights can be defined by the political process for the various objectives of a multidimensional function, improved information about program impacts in terms of all relevant objectives is needed. This will permit the quantitative interrelationships to be highlighted and the social opportunity cost of alternatives to be made more explicit. Planners and elected officials can then make the trade-offs necessary to reach decisions, and improved analysis of those decisions by their respective constituencies can take place [11]. Furthermore, more reasoned and responsible judgments on program cost sharing and reimbursement can result from increased knowledge of the nature and extent of program impacts on various governmental and private group interests.

In summary, the profession's traditional ideas of what constitutes welfare maximization and the methods of empirically implementing our progress toward that state need to be substantially changed. To that end, this paper joins an emerging group [13, 17, 18, 22, 31, 32] to urge that our applied tools of evaluation be altered in an effort to better reflect these concerns.

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Price Elasticities from Panel Data: Meat, Poultry, and Fish*

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National aggregate time series data are not amenable to tracing the consumer response to price changes as these changes occur in the market. This paper is designed to stimulate interest in the development of alternative sources of data and modification in estimating procedures to more nearly approach reality in estimating price-quantity relationships. The analysis was based on data obtained from a group of consuming units on quantities of meats purchased and prices paid. The procedure was designed to trace the consumer response to price changes approximately as they occurred over time.

CONSUMER RESPONSE to changes in the price of foods and other commodities is a problem of long-standing concern to agricultural economists. The problem is generally posed in terms of price elasticities of demand. Parameters desired are simply the changes in quantities purchased by consumers associated with a given change in price, or a schedule of quantities associated with a schedule of prices assuming all other variates remain unchanged.

After considerable time and effort devoted to the problem, there is still limited information available that is widely accepted on specific price-quantity relationships. The major limitation lies in the dearth and inadequacy of data necessary to estimate these relationships. Although pricing experiments [3, 6] have been accomplished, the problem is basically not amenable to experimental control procedures.

Observations generated by the market system have provided the primary source of data for analysis. However, these data are generally time series in nature and available only on a national aggregate basis. Estimates are made (usually by federal agencies) on quantities of commodities produced, aggregate disappearance, and average price at different times and locations. Estimates are also available on population, income, and other variates that influence demand.

Analyses of these types of data with respect to theoretical economic relationships have raised a host of questions regarding estimating procedures and interpretation and have contributed to the development of modified statistical procedures [4, 7] that attempt to deal with statistical problems inherent in the data. Some of the problems of estimation based on aggregate time series data include: (1) a limited range in postulated explanatory variates; (2) multicollinearity in explanatory variates; (3) lagged adjustment in response; and (4) gross averages for long time periods that conceal many individual changes. Perhaps too much effort has been devoted to estimating procedures relative to exploring and developing alternative data sources.

Orcutt [8], in a study concerned with basic data requirements, concluded that social science will remain stunted until better ways are found to secure essential empirical evidence than seems possible as long as dependence on government data collection persists, because such data collection of necessity is done for other purposes and cannot be controlled effectively by researchers. According to Orcutt, basic research aims at discovering the response characteristics of consuming units, firms, governments, and other key actors in social systems. Effective study requires following consuming units, firms, etc., over time rather than following geographic areas over time. Also, with a nonexperimental statistical approach it is frequently essential to work with disaggregated data because of consideration of degrees of freedom, use of control groups, avoidance of multicollinearity, and range in variables of interest.

This paper presents an alternative with respect to source and nature of the data and a more realistic time period. It also raises some questions concerning traditional arguments of consumer response in the short, intermediate, and long run; the nature of the adjustment process; and reversibility of demand functions.

Meat—subdivided into beef and veal, pork,

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poultry, meat mixtures, and fish—was selected for analysis. Meat and its subgroups are subject to frequent price changes compared with other major food commodities. The various kinds of meats are highly substitutable with respect to nutrition and are often interchanged for the sake of variety.

Questions Concerning Price-Quantity Relationships

The question of lagged response to price changes is based primarily on the argument that the full response to a price change is related to time elapsed [7]. Habit and customs in consumption patterns and limited knowledge concerning price changes are alleged to retard consumer response.

Time necessary to develop, promote, and market acceptable substitutes is a factor in consumer response to prices in the longer run. Price supports for cotton and butterfat, for example, provided an incentive for developing substitutes acceptable to consumers. The type of pricing policy, persistency of price levels, and substitution are additional factors that deserve more attention in demand analysis.

Uvacek [12] has posed a question regarding the reversibility of price-quantity relationships. Many commodities, including most meats, are subject to periods of increasing and decreasing prices (or supplies) because of the cyclical nature of production. It might be hypothesized that consumers are responsive to falling prices (increased supplies) for highly preferred foods such as meats but are more reluctant to reduce consumption when prices begin to rise.

Analysts generally have confined their efforts to observations on average prices and quantities for specified time periods, most frequently the year. Time periods of a quarter and a month (in some cases four weeks) have also been analyzed. Ladd and Martin [7] utilized quarterly and four-week data from the Michigan State University Consumer Panel to evaluate alternative estimating procedures with respect to lag in consumer response to price and concluded that most of the adjustment occurs within one year and in some cases does not exceed one month. The same study also indicated that the addition of lagged quantities as an independent variate does not necessarily reduce autocorrelation in the errors.

This paper is predicated on the assertion that the week is the relevant planning and action period with regard to both food purchasing and pricing policy. Changes occur (or are subject to do so) in a time sequence from week to week. Prices can be changed more than once a week, but generally prices are announced by retail stores through newspapers and other news media once each week.

Source of Data

The source of data for this study was a panel of consumers located in Atlanta, Georgia [10]. Food purchases were reported weekly over a five-year period, 1958 through 1962. Data reported included quantity, price, expenditure, and a detailed description as to form, size, and type package. Detailed data were also maintained with respect to household composition, race, income, education, etc. The panel was maintained with replacement at approximately 300 households, and 160 households remained on the panel the entire five years.

Panel data have certain advantages and disadvantages compared with traditional data sources. Specific consuming units react to changes in price or other changes in the market place. This negates the question of simultaneity or whether supply is predetermined, as is the case with national aggregate time series data.[1] It is obvious in this case that prices are predetermined and consumers react to prices.

Panel data also permit observations on consuming units at approximately the time (week) changes occur. In the case of most aggregate market data, only average prices and average quantities for longer time periods can be observed [2]. Also, the panel data permit aggregation for any time period from one week to five years.

The main disadvantage of panel data is the limited population that is represented. Although there is a national panel, maintained by the Market Research Corporation of America, the data are not readily available to most analysts.

Statistical Procedure

The statistical procedure was designed to trace the reaction of a group of consuming units of known characteristics to price changes approximately as they occurred in the market. A first-difference (week-to-week changes) basic analysis was employed.

[1] Fox [5] maintains that in the case of national aggregates for most farm commodities, quantity is largely predetermined. Thus, price-quantity observations approximate a demand schedule.

The model was of the form

$$Q_{it} - Q_{it-1} = a_i + b_i(P_{it} - P_{it-1}) + c_j(P_{jt} - P_{jt-1}) + u.$$

The dependent term, $Q_{it}-Q_{it-1}$, represents the change in purchases of a particular kind of meat (i) from the previous week.

The constant a represents trend in a first-difference equation. For equation in logarithms, the antilogarithm of $(a+2)$ minus 100 represents percentage trend [4, p. 43].

$P_{it}-P_{it-1}$ represents the change in the price of the same kind of meat from the previous week. The coefficient b is an estimate of the effect of a price change on the quantity purchased. For equations in logarithms, b is an estimate of the price elasticity of demand.

$P_{jt}-P_{jt-1}$ represents the change in the simple weighted average price of substitute meats. For equations in logarithms, c is an estimate of the cross-price elasticity of demand.

The u term is a disturbance or residual assumed to be randomly distributed.[2] A basic assumption of the model is that other variates (household composition, income, etc.) do not change in sufficient magnitude from week to week to influence week-to-week changes in meat purchases. Also, the constant a depicts trend over time that may be attributed to these variates. Seasonal adjustment does occur from week to week but is assumed to be a gradual process.

Since a relatively large number (259) of observations were available, positive and negative price changes were analyzed separately to test the reversibility of demand functions.

The same model was also employed to analyze quarterly data with respect to response in average levels of purchases to changes in average prices. A seasonal variate was added to the model for quarterly data. Quarterly data for common quarters (year to year) were utilized to estimate consumer response to changes in average prices from year to year. The Index of Consumer Prices was added to allow for changes in the price level from year to year. This permitted comparisons of initial consumer response to price changes, and average quantities and prices for longer time periods.

[2] A transformation to first differences is suggested for time-sequential data where serial correlation in the residuals is expected [4, p. 30].

Results

Table 1 shows basic characteristics of the data upon which the analysis was based. Week-to-week changes in quantity relative to the mean quantity were considerably larger than price variation. Relative price variability was greater for fish and poultry than for the other meats. Variability in quantity relative to the mean was also largest for poultry.

Table 1. Characteristics of data related to week-to-week variation in prices and quantities of meat purchased, Atlanta Consumer Panel

Meat	Price		Quantity		Correlation between explanatory variates[b]
	Mean	Variation[a]	Mean	Variation[a]	
	dollars per pound	*percent*	*pounds per household*	*percent*	
Beef and veal	0.627	3.56	2.73	12.33	−0.11°
Pork	0.508	3.40	3.66	11.21	0.04°
Poultry	0.364	5.42	2.39	19.67	0.07°
Meat mixtures[c]	0.606	2.85	0.71	8.26	0.09°
Fish[d]	0.504	6.41	0.69	11.28	0.78**

[a] Mean first differences (week to week) relative to mean price and quantity.
[b] $(P_{it}-P_{it-1})$ and $(P_{jt}-P_{jt-1})$, where P_i=price of meat i, P_j =weighted price of substitute meats.
[c] Includes weiners, bologna, and other meat mixtures (largely beef and pork).
[d] Includes finfish and shellfish.
** Significant at the 0.01 level.
° Nonsignificant at the 0.05 level.

The last column of Table 1 indicates the magnitude of the multicollinearity problem between the postulated explanatory variates. Only for fish were price differences between week t and week t-1 highly correlated with differences in the weighted prices of substitute meats. Price changes (as well as quantity changes) tended to alternate between positive and negative. For example, price changes for beef alternated from positive to negative in nearly 75 percent of the week-to-week changes.

Estimated price elasticities of demand and cross-elasticities with substitutes based on week-to-week price changes in logarithms are shown in Table 2. All of the direct price elasticities were of the expected negative sign and all were highly significant ($P<0.001$). Of the five meat groups, pork was most responsive and poultry least responsive to price changes. Cross-elasticities were not consistent with respect to the expected positive sign. Poultry was most responsive (with the expected sign) to changes in the weighted price of substitutes. The negative response in purchases of beef and veal and

Table 2. Estimated price elasticities of demand for meat at retail based on week-to-week first difference price changes, Atlanta Consumer Panel

Meat quantity (dependent)	Price elasticity		Cross-price elasticity[b]		R^2
	Estimate	t ratio[a]	Estimate	t ratio[a]	
Beef and veal	−1.36	9.81	−0.46	2.08	0.28
Pork	−1.66	12.86	0.09	0.46	0.39
Poultry	−0.79	4.54	1.95	4.36	0.13
Meat mixtures	−1.02	5.72	−0.58	3.07	0.15
Fish	−1.58	8.87	0.42	1.85	0.36

[a] Approximate significant levels for t: $t_{0.001}=3.33$, $t_{0.01}=2.59$, $t_{0.05}=1.97$.
[b] Based on a simple weighted average price of substitute meats.

meat mixtures to prices of substitutes might reflect overall adjustment in meat purchases as prices change. Average prices of beef and veal and meat mixtures were appreciably higher than the other meat groups.

Estimated price elasticities of demand for meats in response to positive and negative price changes are shown in Table 3. Except for poultry and fish, the indicated response to negative price changes was greater than the elasticity in response to positive price changes. The difference was greater for pork and meat mixtures. Poultry differed from the other meat groups in that a greater response in purchases to positive price changes was indicated; also, poultry was significantly responsive to changes in the price of substitutes.

Price elasticities of demand for meat based on quarter-to-quarter and year-to-year (common quarter) changes in average price levels are shown in Table 4. Except for poultry, the longer time periods yielded lower estimates of price elasticities of demand. All direct price elasticities were of the expected sign. However, because the number of observations was limited, the statistical reliability was much weaker than the analysis of weekly data.

Table 4. Estimated price elasticities of demand for meat at retail, based on quarter first difference in average prices and common quarter year-to-year average prices, Atlanta Consumer Panel

Meat quantity (dependent)	Quarter to quarter			Year to year		
	Price elasticity		R^2	Price elasticity		R^2
	Estimate	t ratio[a]		Estimate	t ratio[a]	
Beef and veal	−0.97	4.64	0.77	−0.74	3.06	0.68
Pork	−1.09	5.12	0.94	−0.87	7.56	0.86
Poultry	−0.71	3.66	0.93	−0.94	7.01	0.87
Meat mixtures	−1.00	1.33	0.83	−0.53	0.54	0.16
Fish	−0.82	2.61	0.87	−0.36	1.08	0.25

[a] Approximate significant levels for t: $t_{0.001}=4.22$, $t_{0.01}=3.01$, $t_{0.05}=2.16$.

Implications and Limitations

The major contribution of the data, procedure, and results reported in this paper is perhaps to suggest additional research in the area of consumer response to price changes. Although the results were generally statistically reliable, the parameter estimates are based on a relatively small sample of a population in a specific geographic area. Thus, the results in some instances may not be applicable to populations in different locations or different time periods. Meat is subject to frequent and well-publicized[3] price changes. Prices paid for a par-

[3] The mid-week food section of metropolitan newspapers

Table 3. Estimated price elasticities of demand for meat at retail for positive and negative price changes, based on week-to-week first differences, Atlanta Consumer Panel

Meat quantity (dependent)	Positive price changes					Negative price changes				
	Price elasticity		Cross-price elasticity[a]		R^2	Price elasticity		Cross-price elasticity[a]		R^2
	Estimate	t ratio[b]	Estimate	t ratio[b]		Estimate	t ratio[b]	Estimate	t ratio[b]	
Beef and veal	−1.45	6.11	−0.53	1.77	0.24	−1.50	6.33	−0.37	1.10	0.24
Pork	−1.54	6.99	0.29	1.15	0.28	−1.83	7.82	−0.10	0.34	0.34
Poultry	−1.10	3.13	1.54	2.82	0.10	−0.76	2.44	2.20	3.91	0.13
Meat mixtures	−0.93	3.00	−0.58	2.29	0.11	−1.30	4.20	−0.59	2.00	0.15
Fish	−1.67	6.30	0.38	1.16	0.43	−1.63	6.46	0.58	1.75	0.31

[a] Based on simple weighted average price of substitute meats.
[b] Approximate significant levels for t: $t_{0.001}=3.38$, $t_{0.01}=2.62$, $t_{0.05}=1.98$ (observations ranged from 116 to 138 with 3 constants estimated).

ticular kind of meat (beef, pork, poultry, meat mixtures, and fish) is a composite weighted price paid by the panel, although it is recognized that the composition of meat purchases might influence the average price paid.[4]

Consumers react to changes in the price of meats approximately according to theoretical expectations as the changes occur in the market, with a high degree of statistical reliability. Except for poultry, meat purchases were not significantly responsive to changes in the price of substitutes either individually or as a group. This response pattern may be in part attributed to the fact that the average price paid for poultry was appreciably below that of the other meat groups. Poultry was least responsive to changes in its own price and most responsive to changes in the price of substitutes. Although poultry is a relatively inexpensive meat, consumers apparently prefer variety in meat purchases. During the period between 1945 and 1969, poultry (broilers in particular) was substituted for pork as prices of poultry declined relative to pork [9]. However, as the process advanced, greater resistance to further substitution was indicated. This principle is expected to apply to other segments of the meat industry as inroads into the meat market are attempted through increased output and reduced prices.

Results of this study suggest that consumer response (absolute elasticity) to negative price changes is greater than the response to positive price changes for all of the meat groups except poultry. Thus, there is some evidence that the demand relationships (price-quantity) are irreversible for some meats. Consumers indicated more resistance to reduce purchases in response to rising prices than to increase purchases in response to falling prices with comparable price changes.

Irreversible demand relationships have important implications to the various segments of the meat, poultry, and fishery industries. For example, higher levels of consumption gained on the downswing of a price cycle (increasing production) are only partially lost when prices return to the original level on the upswing of the cycle (decreasing production). Thus, the upswing of the production cycle tends to increase demand. Or in terms of price flexibilities, prices rise more rapidly on the downswing of the production cycle than prices fall on the upswing of the production cycle. Irreversibility of demand relationships would also have important implications for price forecasting, as a different demand elasticity (or price flexibility) may apply depending on the direction of change. This suggested pattern of price-quantity relationships deserves further investigation.

Decisions on the part of consumers concerning meat purchases are made generally each week.[5] Also, the week is a relevant period for price changes in the market in response to supply and demand forces. Observations on longer time periods (month, quarter, year) constitute averages for the period, and thus, the responsiveness of consumers to week-to-week price changes is lost in the analysis of such data. Although subject to a small number of observations on quarter-to-quarter and year-to-year observations for common quarters, the results of this study indicate price elasticities of demand for meats are smaller (absolute values) for the longer time periods. However, these results do not necessarily contradict the concept that persistent relatively high (or low) prices encourage the development of substitutes (or substitution for other commodities) and thus lead to larger absolute price elasticities in the long run. These conditions simply did not exist in the market analyzed.

Summary

The purpose of this study was to estimate consumer response to price changes for meats approximately as changes occurred in the market. Estimated consumer response (price elasticities) in meat purchases to price differences were of the expected sign with a generally high degree of statistical reliability. Except in the case of poultry, the meat groups analyzed were not generally responsive (expected sign) to changes in the price of substitute meats. Poultry, a relatively inexpensive meat was least responsive to change in its own price and most responsive to change in the price of substitutes. This pattern indicates a preference for variety in meat purchases within a fairly wide range of price differences. A separate analysis of positive and negative price

is a prime example of advance information available to consumers on prices of meats.

[4] This is a limitation of most data and is not unique to panel data; for example, in national aggregate data the quality of meat is subject to change over time.

[5] Consumption does not necessarily coincide with purchases week by week, as meat may be stored from week to week and longer periods if frozen.

changes by week suggested irreversible demand relations with larger elasticities associated with negative price changes. Estimates of price elasticities were generally progressively smaller (absolute) for the longer time periods—quarter to quarter and year to year for common quarters.

Additional research is suggested to trace out more adequately consumer response to price changes as they occur in the market. It is also suggested that pricing policy and persistency in price levels may play an important role in consumer response to prices and substitution over long time periods. Lack of data on specific consuming units and insufficient range in prices (variation in the postulated explanatory variates) appear to be the major limiting factors with respect to estimating price-quantity relationships. Pricing experiments in conjunction with maintaining data on specific consuming units (consumer panel) are suggested as an alternative to provide data for analysis of price-quantity relationships. A small number of pricing experiments have been conducted and consumer panels have been operated in different locations for limited time periods but not in conjunction with each other.

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Reservation Prices on Credit Use: A Measure of Response to Uncertainty

PETER J. BARRY AND C. B. BAKER

Liquidity in the form of reserved credit is valuable to a business manager because it is available to counter uncertain expectations. This paper investigates the definition and method of estimating values or reservation prices associated with firm liquidity provided by unused credit. A multiperiod linear programming model is taken to reflect the behavior of decision makers in empirically observed situations. Credit reservation prices of decision makers were inferred by comparing growth information for real borrowers with growth information generated by the comparable model at alternative reservation prices. This method succeeded in associating a high credit reservation price with the conservative borrower and low credit reservation prices with a more liberal borrower.

NUMEROUS FIRM growth models have shown that surprisingly rapid growth is possible, e.g., [2, 9]. However, it is difficult to explain why firms do not generally match the model results. Often this discrepancy may arise from failure to recognize the manager's response to numerous sources of business and financial risk and to alternative means of coping with these risks. Previous articles have stressed the need for incorporating the effects of financial strategies and liquidity demands into firm decision making and financial management research [1, 2, 3]. This paper reports a means of estimating values or reservation prices associated with the liquidity provided by unused credit—credit defined as the capacity to borrow.

Problem and Methodology

Value of credit liquidity

Capital limits generally constrain farm planning. Because they are modified by borrowing, these limits are affected by external and internal credit rationing. External credit rationing exists when the borrower has exhausted all sources of loanable funds but still finds the marginal value product of borrowing to exceed the marginal cost of borrowing (both interest and noninterest costs). This situation reflects requirements of lending institutions, loanable funds supplies, or, perhaps most important, the lender's evaluation of the amount and structure of a farmer's credit [1, pp. 518–519; 11; 16].[1]

Previous research [6, 7, 8], as well as empirical observation of debt-equity ratios [10, 12, 13], suggests that farmers do not in general utilize their credit in borrowing to the point where external credit rationing becomes an effective constraint. Self-imposed limitations on credit use provide liquidity in the form of a credit reserve and thus limit exposure of the borrower's equity. Hence, debt aversion is a form of risk aversion and thereby constitutes an important alternative response to uncertainty.

The decision maker must consider potential sources of uncertainty and the alternatives for countering uncertainty.[2] Farm business risks are associated with uncertainty in prices, yields, technology, and general economic conditions, as well as with legal and other institutional uncertainty and uncertain expectations on the behavior of people upon whom the firm may depend. Business risks interact with risks inherent in the financial strategies employed in farm planning. Financial strategies involve financial risks which arise from the use of leverage in the capital structure [3]. We assume that risk aversion is pervasive in economic activities at all income levels, with the possible exception that small stake gambling may be a pleasurable activity for many individuals.

Risk aversion can be expressed in the production, market, and financial organization of the farm firm. In production, risk aversion appears in the search for and adoption of organizational flexibility, product diversification, and informal production insurance (e.g., pesticides and supplemental irrigation), as well as in choices of enterprises with low price and/or yield variability. In marketing, risk aversion can explain the use of forward and futures contracts and, to

[1] This situation bears some resemblance to the corporate cost of capital controversy [17]. We hypothesize that the lender's reactions to different capital structures may raise the firm's cost of capital. This reaction occurs not necessarily as higher interest rates, but in terms of lending limits.

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[2] The theoretical development of decision making under uncertainty is not reviewed here. The reader is referred to the many references available on this subject, e.g., [17].

ome degree, participation in government programs. Financial alternatives for averting risks nclude formal insurance, assets held for their iquidity attributes, and credit held in reserve.

The payoffs associated with these alternatives ire difficult to measure. Furthermore, financial ilternatives for averting risk are often not indeendent of alternatives in other economic areas f the firm. Trade-offs generally exist between neans of averting risks in the production, narketing, and financial organization of the irm. Thus, emphasis on one means of countering uncertainty (e.g., liquidity) may allow a lecision maker to make more daring choices in ther firm areas (e.g., product specialization).

It is reasonable to expect cash grain farmers o be homogeneous with respect to many of the ilternatives for averting risk. Cropping patterns ind practices among farmers in a given geographic region are in general similar. Most armers participate to a similar degree in government programs. Few farmers hedge their rop or use other forward contracts. Most armers use formal insurance in insurable situaions: life, fire, hail, and other personal property or liability contingenices.

Given homogeneity in the use of these means o counter uncertainty, variation in the demand or credit liquidity may be the most visible mpirical feature. In addition, liquidity is robably the most general means of countering ıncertainty and provides a minimum effect on he economic organization of the firm. At first lance the expected effect might occur only as educed scale. However, Baker [1] has shown hat liquidity attributes of the firm's organizaion may logically be expected to influence illocative decisions in production, marketing, nvestment, and finance. Thus, the liquidity issociated with unused credit, together with mpirical observations of debt aversion, sugests that credit maintained as a reserve has value to the decision maker.

Equilibrium in credit use

In an optimal allocation of credit between use or loans and use in reserve the decision maker must consider the value of the credit reserve as well as the value of the borrowed funds. Presumably the credit reservation price rises as further borrowing depletes the credit reserve [3]. Conversely, the value of additional units of unused credit declines as borrowing declines.

This situation is portrayed by liquidity value curve U_1 U_1 in Figure 1. The more averse the

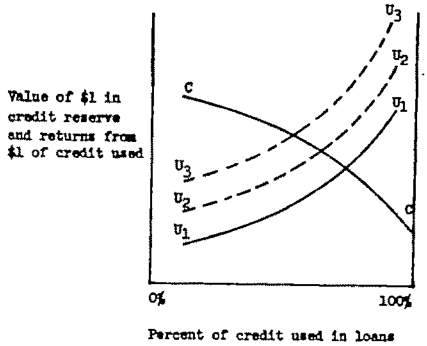

Figure 1. Credit-liquidity equilibrium

decision maker is to debt, the higher is the position of UU. It seems plausible to assume that an individual's liquidity value curve could shift and change shape over time as a result of experience, age, preference changes, or other changes that alter the importance of risk to him.

It may pay the farmer to borrow because of leverage attained through the use of borrowed funds. Thus, the cost of maintaining liquidity in the form of unused credit is an opportunity cost reflecting the return foregone by rejection of borrowing as an alterntive use of credit. The law of diminishing marginal returns indicates that the returns from successive units of resources and resource services acquired with the use of loan proceeds (i.e., used credit) will decline at an accelerating rate, as indicated by liquidity cost curve CC in Figure 1.

The intersection of the liquidity value and liquidity cost curves indicates a credit-liquidity equilibrium for a decision maker. The marginal value and marginal cost of unused credit are equal at this point.

Estimation of reservation prices

Credit reservation prices could be easily determined if farmers could accurately specify their minimum required rates of return on borrowed funds.[3] But farmers in general are not readily prepared to provide such information. Hence, an alternative method of inference was devised.

Information on decision elements and out-

[3] The reservation price approach is comparable to the required rate of return on investments in capital budgeting techniques. However, the reservation price approach may provide greater explanation of decision-making behavior since it reflects the value of a specific means of countering uncertainty—a liquid credit reserve.

comes for a cash grain farm in Central Illinois was empirically derived from historic records. This information included input data, resource levels, consumption patterns, credit use over time, rates of firm growth, and the production and market organization. This information was incorporated in a multiperiod linear programming model to portray a farm decision-making situation over a historical time period. Thus the performance of the farm firm was known.

Risk aversion was reflected in the valuation of a credit reserve maintained throughout the planning horizon of the model. The objective specified in the model included asset equity measured at the end of the planning period, consumption during the planning period, and liquidity management, as reflected by the reservation price for credit. A specified consumption function determined the allocation of disposable income between consumption and savings.

Since financial protection provided by liquidity is an important decision objective, reservation prices were introduced as positive objective function values in slack vectors of credit constraints in the programming model. Other means could have been used to identify reservation prices for credit: the addition of a noninterest cost to the interest rate on borrowed funds or the specification of a negative rate in the objective function for borrowing activities. Alternatively, one might have included a farmer-imposed credit constraint in the model, using shadow prices on this constraint as measures of reservation price on credit.

Production and marketing alternatives were limited in the model to allow emphasis on alternative financial specifications. The limited alternatives also accorded well with empirical experiences of cash grain farmers in Central Illinois.

Reservation prices were inferred for decision makers by comparing growth information for real borrowers with growth information generated by the comparable models at alternative reservation prices. Since costs and return per production unit were assumed given over time, a constant liquidity cost function was defined. Consequently the parametric variations in reservation price implied a ranging of the liquidity value curve as indicated by curves U_2 and U_3 in Figure 1. Thus, the model solutions at varying credit reservation prices reflect equilibrium points between a constant liquidity cost function and a shifting liquidity value function. In the process the liquidity cost curve for the planning horizon is traced out with linear segments because the linear programming technique was used. Given these equilibrium points between the value and quantity of credit reserved, the task is to find on the derived cost curve the price or range of prices that is consistent with the quantity of credit reserved by real world decision makers.

The Linear Programming Model

The linear programming model yielded a mutually optimal solution among production, marketing, investment, and financing decisions. The choice of linear programming implies that farmers are optimizers subject to decision elements, i.e., alternatives, constraints, and objectives, that can be accurately portrayed in the model. Furthermore, in using linear programming, one assumes that land investments can be treated on an incremental basis with emphasis on total investment within the planning horizon.

The linear programming model covered 21 years, divided into seven three-year periods.[4] Coefficients, stated in annual terms, were averages over each three-year period. The operator began as a full tenant. Data were collected from summaries of farm records for the 1948–1968 period. They included crop yields and prices, cost of production, land values, consumption functions, tax rates, labor requirements and wage rates. Each period of the model was divided into four seasons to allow for detailed intrayear cash flows.

Components of the model are identified for two periods in Table 1. The columns and rows for respective periods represent blocks of activities or constraints. Hence the letters refer to submatrices of coefficients. Interperiod transfers are shown for resources, debt, and cash. The objective was postulated as a maximum of the value of all asserts minus debts at the end of the planning period, plus the value of all consumption expenditures above a specified minimum during the planning period, plus the value of credit reserves during the planning period, subject to constraints in the categories indicated.

Production is constrained by resource limits on land, labor, and capital capacities. Production constraints may be increased over time by investment choices and labor hiring. Financial

[4] Complete specification of the linear programming model may be found in [4].

Table 1. Outline of linear programming model used to infer credit reservation prices

Constraint	Produce and sell products	Buy resources		Borrow (short term)	Service debt		Pay tax, consume and save	Transfer cash	Reserve credit	Constraint	
		Cash	Loan		Repay	Transfer				Relation	Level
Objective		C_N	C_N			$-C_N$	C_n[a]	C_N	C_n[a]	E	Max
Period n[a]											
Land	A	$-A$	$-A$							LE	B
Labor	A	$-A$	$-A$							LE	B
Capital	A	$\pm A$	$\pm A$							LE	B
Cash	$\pm A$	A	A	-1	$1+i$		A	1		E	F
Credit	$-A$	$\pm A$	A	A					1	E	F
Debt			$-A$	-1	1	1				E	O
Tax	$-A$	A	A				A			LE	F
Consumption							1			GE	H
Period $n+1$[a]											
Land		$-A$	$-A$							LE	B
Labor										LE	B
Capital		$-A$	$-A$							LE	B
Cash								-1		E	F
Credit		$\pm A$	$\pm A$							E	F
Debt						$-1+i$				K	O
Tax										LE	F
Consumption										GE	H

[a] n = respective period $(1 \cdots N)$

components in the constraint set include cash, credit, debt, and tax constraints. Cash rows account for the cash flow of the business over time. Non-real estate credit and real estate credit are available for borrowing or for reserve. The credit constraints are modified by an asset acquisition, income expectations, borrowing, repayment commitments, and appreciation or depreciation of capital values as these materialize over the planning horizon. The debt row accounts for debt repayment or transfer to the following period.

Tax bracket rows account for all activities that affect taxable income. A minimum level of consumption, which may increase over time, is required before any funds are available to add resources to the firm.

A corn-corn-soybeans rotation is specified as the production and marketing activity in each period of the model. Growing crops use land, labor, cash, and machinery and storage capacity. They generate cash, taxable income, and non-real estate credit.

Resource acquisition includes labor hiring and investment in capital assets. Investment choices were limited to land purchase accompanied by required additions of machinery and storage capacity. This limitation accords with the real world of the cash grain farmer. Cash purchase, mortgage financing, and intermediate loans were cast as financing alternatives for the investments. Objective function entries represent the asset's value, appreciated or depreciated, at the end of the planning period. Credit is absorbed by borrowing to finance assets and is further reduced by debt repayment commitments [11]. Credit is modified in following periods as asset equity is increased by debt repayments and by the appreciation and depreciation of asset values. Depreciable assets are maintained by depreciation allowance on cash in the production activities of following periods. Tax row entries reflect tax deductible expenses associated with investments: interest on debt, taxes, and depreciation.

Short-term borrowing generates cash and debt balances and absorbs non-real estate credit at a specified rate. Debt servicing activities allow repayments of principle and interest or transferral of debt and accrued interest to the following period. In the final period the objective function is reduced for each dollar of outstanding debt.

Each dollar of taxable income above the minimum consumption level is divided among taxes, consumption, and savings. Consumption and taxes are specified respectively by a declining marginal propensity to consume and a progressive tax rate structure.[5] The consumption schedule also declines over time, reflecting a time preference for early consumption. The respective period's consumption is reflected in values of the objective function entries.

[5] See [4, 15] for further elaborations on tax and consumption specifications in linear programming models.

Table 2. Inferred credit reservation prices for case farms

	Borrower One	Credit reservation prices		Borrower Two	Credit reservation prices	
		.25	.30		.01–.02	.03
Borrowing period, years[a]	16	15	15	7	6	6
Beginning net worth, dollars	13,087	17,469	17,469	21,504	39,030	38,970
Ending net worth, dollars	86,143	67,513	64,111	108,070	84,506	80,703
Net worth growth, dollars	73,056	50,044	46,642	86,556	56,476	41,733
Average annual net worth growth, dollars	4,583	3,336	3,109	12,365	7,579	6,955
Average acreage farmed annually, acres	485	347	341	667	406	387
Average annual net worth growth per acre, dollars[b]	9.45	9.61	9.11	18.54	18.66	17.97

[a] Growth data for shorter model-planning horizons were calculated to validate comparison with real growth situations involving similar time periods and similar stages within the process of growth.
[b] Average annual growth in net worth is determined by dividing total net worth growth by the number of years in the model. Average annual net worth growth is then divided by the number of acres farmed annually in order to determine average annual net worth growth per acre.

Vectors are provided to transfer surplus cash savings from season to season, period to period, and to the objective function at the end of the planning horizon. Credit reserve activities allow the reservation of non-real estate credit and real estate credit as a source of firm liquidity.

Empirical Application

The results of the preconstructed model are compared with the growth of two cash grain farms for which information on growth and credit use was gathered directly from the financial records of a production credit association from whom they had borrowed continuously. The model was so specified as to resemble the actual farms over the historical period, in terms of their pattern of land control. The model solution indicated a transition from tenant to part-owner status, with owned land about one quarter of total land operated. The case farms also acquired greater ownership over time, with owned land less than one quarter of the total land operated.

Growth was measured on a per acre basis to account for differences in initial farm size between the model and case farms. This is warranted by empirical evidence which suggests that constant returns to size may exist over the limits of production conditions of this study [5, 14]. Thus, with discrepancies in initial farm size removed and other variables held constant, differences in reservation prices on credit can explain differences in growth rates. Furthermore, because of differences in the length of historical period between the model and case farms, growth is measured on the basis of average annual net worth growth per acre.

Table 2 reports growth information for the case farms and growth information generated by the comparable model at the indicated reservation prices. Borrower One's net worth increased by $73,056 over a 16-year period, an average annual growth of $4,583. Over this period he farmed an average of 485 crop acres annually. Thus, his average annual net worth growth per acre was $9.45. Borrower One's growth rate was associated with a credit reservation price in the area of .25 to .30, since model growth rates were $9.61 and $9.11 for these respective prices. This reservation price range implies a relatively high degree of debt aversion for Borrower One. His lender described him as a "conservative" credit user. This was further substantiated by his relatively high average annual ratio of net worth to total assets (.905) and a relatively low index of available non-real estate credit that was actually used (29.9 percent).[6]

Borrower Two's net worth increased by $86,566 over a seven-year period, an average annual growth of $12,365. Over this period he farmed an average of 667 acres annually, with an average annual growth in net worth per acre of $18.54. Borrower Two's growth rate was associated with a credit reservation price in the range .01 to .03, which implies a relatively low degree of debt aversion. His lender described

[6] Estimates of each borrower's available credit were based on rules of thumb reflecting lender evaluation of the farmer's assets and income expectations from production activities. Since these rules of thumb were applied consistently over time and between different borrowers, each borrower's credit was measured on a common basis. Available credit was used at various rates, depending on the amount and purpose of historical borrowing.

him as a "liberal" credit user. This is substantiated by his relatively low average annual equity ratio (.496) and a relatively high index of non-real estate credit use (94.9 percent).

Concluding Comments

Debt aversion was considered as the sole variable with which to distinguish response to uncertain expectations by cash grain farmers. Such an assumption might not hold as well for other types of farmers. Future research might usefully attempt to explain risk-averting strategies for other farm types and analyze the risk-return payoffs associated with combinations of risk-averting alternatives. For example, skills in hedging on the futures market may diminish the need for credit liquidity; or more comprehensive insurance schemes may reduce the value of credit liquidity for individual managers. Finally, the influence of each risk-averting alternative on the credit capacity of the firm should not be neglected.

The validity of the inference method in this study depends upon the large number of parameter values, activities, constraints, and objectives taken as given in order to imply a credit reservation price for a decision maker. To achieve a degree of empirical generality it would be useful to have estimates of the influence on growth of factors other than liquidity, including random disturbances. Linear programming models as generally used do not generate error estimates associated with results. Useful results might be obtained by inputting specified parameters at values determined by sampling from derived probability distributions.

Financial management research as well as education activities with farmers and lenders must increasingly take into account the manager's attitude toward risk and alternatives for countering risk. The decision maker's response to research results, extension advice, and other management council often depends on both the farmer's and the adviser's recognition of uncertainty associated with the recommendations.

Finally, information on credit reservation prices prevailing in agriculture may allow more assessment of the impact of certain macro finance policies. For example, if the total flow of funds into agriculture were increased, knowledge of debt aversion behavior would help in forming estimates of the pattern of use of funds and might enable more precise identification of emerging, successful farmers.

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Effects of Split-Demand and Slaughter-Capacity Assumptions on Optimal Locations of Cattle Feeding*

LARRY N. LANGEMEIER AND ROBERT M. FINLEY

Many studies have concentrated on the optimal location of cattle feeding. Two major limitations of such studies have been (1) reliance on a single demand function for beef and (2) failure to consider existing slaughter capacities. By utilizing separated or split-demand functions for beef and explicitly accounting for present regional slaughter capacity, quite different patterns of beef feeding emerge. In comparison with actual feedlot locations, the models used showed considerable improvement over most previous models. More importantly, results compare favorably with recent trends in the location of cattle feeding.

FACTORS AFFECTING location of feedlots in various regions of the country have been the subject of some study and much speculation. Studies by Judge and Wallace [2], Williams and Dietrich [9] and Rizek, Judge, and Havlicek [5] have contributed to an understanding of the interrelationships of the complex livestock economy. Research efforts by King and Schrader [3, 6, 7] are especially important, primarily because they not only considered the optimal transportation patterns of beef but also incorporated cattle-feeding activities in the models. Although these studies were innovative and of great interest from a methodological viewpoint, "optimal" marketings sometimes bore little relationship to trends. Our contention is that two major variables must be introduced in the models to make such studies of practical value to those interested in the cattle-feeding industry:

(1) "Splitting" the demand for beef into two distinct demands—fed beef and nonfed beef components.

(2) Accounting for present regional slaughter capacity.

Unless those constraints are included in a spatial equilibrium model, the results may be misleading and of only limited value in an applied sense. Therefore, a model of the cattle feeding industry is presented incorporating the split-demand and slaughter-capacity assumptions. The model is patterned basically after previous models to allow comparisons, if that is appropriate.

The Spatial Equilibrium Model

A single demand for beef seems to be unrealistic, considering that consumers differentiate between different qualities of beef and that the important variables of price, income, and population influencing this pattern of beef consumption vary widely among areas. In this model a region's demand for beef was separated into two distinct but aggregative entities—a demand for fed beef and a demand for nonfed beef. This separation of total beef demand eliminates the possibility that a region's beef consumption might be satisfied entirely by nonfed beef, which otherwise could occur in regions that are low in population and/or have a large number of beef and dairy cows.

Neither price nor quantity data were considered adequate to fit statistical demand functions for each region. Therefore, the demand equations were derived from a simultaneous equation analysis of the beef industry by Langemeier and Thompson [4]. The respective beef demands on a per capita basis were:

$$f = -28.3 - 0.66P^f + 0.30P^n + 0.068I$$

$$n = 47.7 + 0.40P^f - 0.52P^n - 0.017I$$

where

f = per capita demand for fed beef,
n = per capita demand for nonfed beef,
P^f = retail price of fed beef,
P^n = retail price of nonfed beef, and
I = per capita disposable income.

Demand elasticities derived from the above equations were used to adjust the demand equations to the 1964 base year. Conversion to the wholesale level was accomplished by adjusting the constant term by the quantity effect as-

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sociated with the average retail-wholesale price spread for fed beef and nonfed beef.[1] Regional demand estimates of beef consumption were based on differences in consumer disposable income and population levels. The respective regional total beef demands were:

$$G_i(f_i) = DM_i = G_i(-67.26199 - 0.97266P_i^f + 0.48447P_i^n + 0.07816I_i)$$

$$G_i(n_i) = DN_i = G_i(60.09300 + 0.47995P_i^f - 0.68909P_i^n - 0.01584I_i)$$

where

f_i = per capita demand for fed beef in region i,
n_i = per capita demand for nonfed beef in region i,
DM_i = total demand for fed beed in region i,
DN_i = total demand for nonfed beef in region i,
G_i = population in region i,
P_i^f = wholesale price of fed beef in region i,
P_i^n = wholesale price of nonfed beef in region i, and
I_i = per capita disposable income in region i.

The demand constraints were:

$$\Sigma_j M_{ji} \leq DM_i$$

$$\Sigma_j N_{ji} \leq DN_i$$

$$\Sigma_j M_{ji} + \Sigma_j N_{ji} = DM_i + DN_i = B_i$$

where

$\Sigma_j M_{ji}$ = quantity of fed beef shipped from region j to region i,
$\Sigma_j N_{ji}$ = quantity of nonfed beef shipped from region j to region i,
B_i = total demand for beef in region i, and $i = 1, 2,$ ———, 20 and $j = 1, 2,$ ——20.

As income and population were constant for the year under study, the demands for fed and nonfed beef, and thus total beef, depend on wholesale market prices of fed and nonfed beef. In the model the supply of grass-fed beef plus feedlot-finished beef must satisfy the fed beef demand whereas the supply of nonfed beef—cull animals and imports—must equal the demand for nonfed beef. The equilibrium condition—model solution—is obtained when in each region the supply of beef equals the demand for beef consistent with an equilibrium set of fed and nonfed beef prices. An iterative process is required to achieve an equilibrium, which is reached when the above relationships become equalities.[2]

Most studies specify that slaughter plants exist at feedlot locations unless cattle feeding areas determine the location of slaughter facilities [9, pp. 26–28]. The trend in recent years has been one of decentralization in the location of slaughter plants. That is, plants have moved away from industrial centers and nearer to the supply of feedlot-finished cattle; in general. however, the new plants have relocated in the same region as the original facility. The recent investments in slaughter plants near feeding areas may be one of the basic determinants of cattle-feeding locations. Existence of these facilities not only lowers transportation costs to the cattle feeder; it also allows a direct outlet for his cattle either through buyers or contract feeding. Because the actual total beef slaughter capacity of each region was unknown, regional slaughter capacity rates were estimated. Capacity of fed beef slaughter was computed as a residual, using actual total slaughter rates and assuming that beef other than feedlot fed is slaughtered within the region of production.[3]

[1] The same procedure was used by King and Schrader [3, 6, 7] to convert a retail total beef demand equation to regional beef demand estimates at the wholesale level.

[2] The procedure used in revising fed and nonfed prices and quantities in successive iterations of the problem was similar to that used by Judge and Wallace [2] to obtain equilibrium regional price differentials, except that both fed and nonfed beef prices were revised until an equilibrium was reached.

[3] This assumption does not differ greatly from actual practice, since high transportation costs of live animals usually prevent transporting low-grade beef cattle and cull animals for long distances. Thus, the regional slaughter capacity for feedlot beef was equal to the total number of beef slaughtered in a region minus the nonfed and grass-fed beef slaughtered in that region. The above figure was converted to a liveweight basis by assuming that the weight of feedlot-finished beef in each region equaled the national average of 1,065 pounds. Conversion of live weight to carcass weight was accomplished by using a dressing percentage of 58. Since five regions had negative slaughtering capacity, these regions were set at zero and the remaining regional capacities adjusted. The total fed beef slaughter capacity estimated by the above procedure was 10,406 million pounds. In the model, slaughter capacity constraints were formulated so that production of feedlot-finished beef was equal to or greater than capacity. In other words, each region's capacity had to be fulfilled by the feedlot beef produced ln that region and/or by the cattle supplied from another region. Since total production of fed beef is unknown until the results of the model are obtained, total slaughter capacity was adjusted to offset the possibility of the model deterioration. The effect of this adjustment was known, since regional capacity remains the same on a relative basis.

Table 1. Notation used in the two-region example of the spatial equilibrium model

Item	Intermediate factors					Carcass beef		
	Feeder cattle	Concentrate	Roughage	Slaughter cattle	Slaughter capacity	Fed	Nonfed	Total
Quantity available in region i	F_i	C_i	R_i		S_i	M_i	N_i	
Quantity produced in region i				$(M_i')^*$		M_i		
Quantity used or demanded in i	F^i	C^i	R^i			DM_i	DN_i	B_i
Quantity shipped from i to j	F_{ij}	C_{ij}	R_{ij}	S_{ij}		M_{ij}	N_{ij}	$M_{ij}+N_{ij}$
Transportation costs per unit	T_{ij}^f	T_{ij}^c	T_{ij}^r	T_{ij}^s		T_{ij}^f	T_{ij**}^n	
Price to feeder for carcass beef in region i shipped to region j						P_{ij**}^f	p_{ij}^n	

* Feedlot-finished cattle are expressed in 1,000 pounds of carcass beef or the equivalent of 1,827 pounds of live cattle.
** Prices for carcass beef are net prices, and therefore:
$P_{ij}^f = P_j^f - T_{ij}^f$ where P_j^f is the wholesale price of fed carcass beef in region j.
$P_{ij}^n = P_j^n - T_{ij}^n$ where P_j^n is the wholesale price of nonfed carcass beef in region j, where
$T_{ij}^f = T_{ij}^n$.

The major determinants of location considered in the model, other than regional demands for fed and nonfed beef and regional slaughter capacity, were (1) transfer cost of slaughter cattle, carcass beef, and production inputs of roughages, concentrates, and feeder cattle; (2) feed conversion by region; and (3) regional supplies of production inputs of roughages, concentrates and feeder cattle.[4]

Feed efficiency rates were developed from data reported by states on total pounds of beef production and total amount of concentrates, roughages, and silage fed [8]. To achieve a greater degree of accuracy the total amount of concentrates fed in each region was divided into various feeds in accordance with the proportion a specific feed was to that region's total regional production of concentrates. The regional supply of concentrates, roughages, and silage fed was converted to a net energy basis; and an index of therms per pound of gain was computed. These indexes were then adjusted to an index of one to obtain the regional feeding efficiency rates, which were used to adjust the rate of gains of feedlot cattle in determining the regional factor requirements for the cattle production activities used in the model.

Nonfed beef was defined as the total supply of cull dairy and beef cows, cull dairy and beef heifers, bulls, and imports of carcass beef. Grass-fed beef was composed of steers and heifers that are fattened on grass but are not entered into feedlots. The total number of nonfed and grass-fed cattle slaughtered equaled the total number of cattle slaughtered in 1964 minus the number of feedlot-finished cattle marketed. Federal marketing statistics were used to divide the total number of nonfed and grass-fed cattle slaughtered into various classes of cattle —cull dairy cows and heifers, cull beef cows and heifers, bulls, and steers and heifers not feedlot-finished. Factors were then calculated by using the total of each class of cattle slaughtered in proportion to national inventory numbers; and these factors were applied to regional January 1 inventory numbers as a basis for obtaining the regional estimates of the number of nonfed and grass-fed cattle slaughtered. These regional values were converted to a liveweight basis by assuming that the weight of each class of cattle in each region equaled the national average for that class. Regional estimates of predetermined nonfed and grass-fed carcass beef were obtained by converting live weight to carcass weight by using dressing percentage of 55.5 and 58.0 for nonfed and grass-fed cattle, respectively.

The mathematical notation shown in Table 1 is the basis for the formulation of the simple two-region example of the spatial equilibrium model in Table 2. The supply of factors available to a region for cattle feeding depends on the regional supply and factor shipments. Shipments of beef are constrained by the amount available plus the amount of beef produced by the production activities. Slaughter cattle shipments are constrained by regional slaughter capacity. The equilibrium condition exists when the factor-product allocation cannot be changed without reducing the return to factor owners and when each of the separate beef markets is in equilibrium.

Necessarily, the model analyzed was static. Perfect competition was assumed to exist on

[4] Procedures used to formulate these were essentially the same as those used by King and Schrader.

Table 2. A two-region example of the spatial equilibrium model[a]

Shadow prices	Objective function		P_{11}^f	P_{12}^f	P_{21}^f	P_{22}^f	L_{1A}	L_{1B}	L_{2A}	L_{2B}	T_{12}^f	T_{21}^f	T_{12}^c	T_{21}^c	T_{12}^r	T_{21}^r	P_{11}^n	P_{12}^n	P_{21}^n	P_{22}^n	T_{11}^s	T_{12}^s	T_{21}^s	T_{22}^s
	B_i	Code	M_{11}	M_{12}	M_{21}	M_{22}	M_{1A}'	M_{1B}'	M_{2A}'	M_{2B}'	F_{12}	F_{21}	C_{12}	C_{21}	R_{12}	R_{21}	N_{11}	N_{12}	N_{21}	N_{22}	S_{11}	S_{12}	S_{21}	S_{22}
V_1	M_1	$\geq$	1	1																	−1		−1	
V_2	M_2	$\geq$			1	1																	−1	−1
V_3	F_1	$\leq$					F_{1A}	F_{1B}			1	−1												
V_4	F_2	$\leq$							F_{2A}	F_{2B}	−1	1												
V_5	C_1	$\leq$					C_{1A}	C_{1B}					1	−1										
V_6	C_2	$\leq$							C_{2A}	C_{2B}			−1	1										
V_7	R_1	$\leq$					R_{1A}	R_{1B}							1	−1								
V_8	R_2	$\leq$							R_{2A}	R_{2B}					−1	1								
V_9	B_1	$\leq$	1		1												1		1					
V_{10}	B_2	$\leq$		1		1												1		1				
V_{11}	N_1	$\leq$															1	1						
V_{12}	N_2	$\leq$																	1	1				
V_{13}	DN_1	$\leq$															1		1					
V_{14}	DN_2	$\leq$																1		1				
V_{15}	Z_1	$\leq$					−1	−1													1	1		
V_{16}	Z_2	$\leq$							−1	−1													1	1
V_{17}	S_1	$\leq$																			1		1	
V_{18}	S_2	$\leq$																				1		1

[a] The factor requirements for beef feeding activities are denoted as F_{iA}, C_{iA}, and R_{iA} for ration A (F_{iB}, C_{iB}, and R_{iB} for ration B) for feeder cattle, concentrates, and roughages, respectively. These factor requirements are denoted as F^i, C^i, and R^i in Table 1. The appropriate nonfeed cost (L_i—) associated with each production activity appears in the objective function.

both sides of the market, with the United States divided into 20 regions (Figure 1).

Feeder cattle, concentrates, and roughages were not explicitly priced in the model. The number of feedlot-finished cattle is great enough to exert influence on the factor prices in the various regions. If the present location of cattle feeding is nonoptimum, the actual prices of factors will be nonoptimum; therefore, use of the factor prices would create an influence on the results that would not necessarily be optimum. Hence the number of cattle fed in a region is determined simultaneously in the equilibrium flow of factors. The cost of feeding in a region is derived in the model rather than determined by existing costs.

Analysis of Optimal Solutions

In Table 3, the location of cattle feeding in 1964 is compared with Model A, in which allowances were made for a split demand and for slaughter capacity, and with Model B, in which

Figure 1. The 20 regions used in the cattle-feeding location model

Table 3. Comparison of cattle marketings by regions, 1964: Actual; Model A; Model B

Region	Number of fed cattle			Percent of total fed cattle		
	Actual	Model A	Model B	Actual	Model A	Model B
1	437	—	—	2.5	0	0
2–3	2,053	520	486	11.9	3.0	2.9
4	39	347	351	.2	2.0	2.0
5	375	407	742	2.2	2.4	4.3
6	596	496	496	3.5	2.9	2.9
7	183	1,050	958	1.1	6.1	5.5
8	943	935	493	5.5	5.4	2.9
9	158	384	100	.9	2.2	.6
West	4,784	4,139	3,626	27.8	24.0	21.1
10	793	2,265	2,786	4.6	13.1	16.1
11	3,104	2,845	3,884	18.0	16.5	22.5
Central Plains	3,897	5,110	6,670	22.6	29.6	38.6
12	1,226	1,478	1,757	7.1	8.6	10.2
Southwest	1,226	1,478	1,757	7.1	8.6	10.2
13	884	1,406	739	5.1	8.2	4.3
16	876	326	816	5.1	1.9	4.7
Lake States	1,760	1,732	1,555	10.2	10.1	9.0
14	4,789	4,676	3,527	27.7	27.1	20.4
Corn Belt	4,789	4,676	3,527	27.7	27.1	20.4
15	131	—	—	.8	0	0
17	130	—	—	.7	0	0
19	274	—	—	1.6	0	0
20	97	—	—	.5	0	0
South	633	0	0	3.6	0	0
18	174	127	127	1.0	.7	.7
New England	174	127	127	1.0	.7	.7
Total	17,262	17,262	17,262	100.0	100.0	100.0

Source: Actual number of fed cattle, [9].

only the split-demand assumption was used.

In Model A, cattle feeding was specified in all but five regions and four of these were primarily in the South. The location efficiency measure[5] of cattle feeding was .78, suggesting that the adjustments necessary to achieve equilibrium in the beef sector are not large. The largest discrepancy between optimum and actual location of cattle feeding was centered in the nonfeeding regions of the South and Northwest (regions 1, 15, 17, 19, 20). Principal disadvantage of those regions appear to be lack of concentrates and/or roughages, as well as low slaughter capacities, which discourage cattle feeding. However, these five regions actually fed only about 6 percent of the cattle in 1964 and hence were not important cattle-feeding regions. Greatest regional variance between

[5] The measure used to determine the efficiency of regional distribution was developed by Henderson [1]:

$$\frac{\text{Total efficient output} - \dfrac{\text{Misallocated output}}{2}}{\text{Total efficient output}}$$

where misallocated output was defined as the sum of the absolute deviations of the actual from the estimated.

Table 4. Comparison of cattle marketings by areas for 1964, 1968: Model A, and Model B

Area	Percent of total fed cattle			
	Actual 1964	Actual 1968	Model A	Model B
West	27.8	25.1	24.0	21.1
Central Plains	22.6	23.9	29.6	38.6
Southwest	7.1	10.1	8.6	10.2
Lake States	10.2	9.9	10.1	9.0
Corn Belt	27.7	27.3	27.1	20.4
South	3.6	2.9	0	0
New England	1.0	.9	.7	.7

Sources: Actual percent of total fed cattle, [9, 10].

optimal and actual marketings was only seven percentage points, occurring in the Central Plains (regions 10, 11). This variance is minor, especially when compared with results of other studies.

In Model B, cattle-feeding numbers remained the same as in Model A for only the South and New England areas, but more cattle were fed in the Central Plains and fewer in the Corn Belt and West. Only minor changes occurred in the Southwest and Lake States. The efficiency index for Model B dropped to .72, a decline from .78 for Model A, but still indicating that adjustments to achieve equilibrium are not large.

In order to compare recent trends in cattle-feeding location with optimal locations specified in Models A and B, Table 4 shows the percentage of total cattle fed in various areas for 1964, 1968, and the two models of this analysis. The direction of change from 1964 to 1968 in actual fed cattle marketings for the areas was identical with that between 1964 and the optimal cattle-feeding locations suggested by Models A and B. Although the direction of change was the same, Model B (slaughter constraints removed) had the largest discrepancy from the actual pattern of feeding location.

Summary

Several effects of the slaughter capacity and the distinct demand assumptions were apparent. First, the cattle-feeding position of those areas that currently have a large number of beef and dairy cows, that is, a large supply of predetermined nonfed beef production, was enhanced by the separation of the total demand for beef into fed and nonfed components. Second, because a region had to feed cattle and/or ship in fed carcass beef, the distinct demand assumption caused cattle feeding in each region to be more economical relative to other regions since intra-regional shipments of carcass beef had a cost advantage over interregional transfers. Third, the specification of slaughter capacity constraints in the model enhanced a region's cattle-feeding position because live cattle shipments have higher costs relative to shipments of carcass beef.

In comparison with actual feedlot locations, both models indicate some room for improvement with efficiency measures of .78 and .72; nonetheless, they were an improvement over many previous models.[6] More importantly, both models compared favorably with recent trends in the location of cattle feeding. The direction of change from 1964 to 1968 in actual fed cattle marketings for the areas was identical with that between 1964 marketings and the optimal cattle-feeding locations suggested by Models A and B (Table 4). We contend that our study is a refinement rather than a refutation of previous studies; and we emphasize that in order for models to have applied value a careful specification of basic assumptions should precede any detailed equilibrium analysis of complex industries such as beef feeding.

An additional variable that could be considered in the spatial model, to reflect the competitive forces in the beef sector, would be the subdivision of the predetermined supply of beef into three groups: grass-fed beef of high quality, nonfed beef, and functional beef. The functional supply would become variable, like feedlot cattle, in the sense that its classification as fed or nonfed beef would depend on economic conditions. If economic, these cattle can be fed a low-concentrate ration, coupled with grazing, and thus marketed at a quality comparable to grass-fed beef of high quality. If not economic to feed, this supply of cattle would revert to the nonfed beef supply.

[6] For example, in the King-Schrader studies, the location efficiency varied from .44 to .65. It should be pointed out that in one model a separation of the total demand for beef into fed and nonfed beef components was made in that the proportion of total consumption that was fed beef was the same for all regions. The proportion that was fed beef was set equal to 46 percent for each region, with no allowance being made for regional differences in population and income which influence the regional beef demands [3, pp. 388-389].

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PROCEEDINGS PAPERS

WINTER MEETING OF THE AMERICAN AGRICULTURAL ECONOMICS ASSOCIATION WITH ALLIED SOCIAL SCIENCE ASSOCIATIONS

Detroit, December 27–29, 1970

NEW ECONOMIC ROLES FOR THE RURAL ENVIRONMENT

CHAIRMAN: MICHAEL F. BREWER, RESOURCES FOR THE FUTURE, INC.

Some Key Issues and Challenges Posed by Nonagricultural Demands for Rural Environments*

RAYMOND D. VLASIN

THE ECONOMIC roles for the rural environment, or more correctly, rural environments, extend increasingly beyond the agricultural sector and agricultural demands for rural resources. Rural environments are increasingly serving diverse ends that emanate from nonagricultural sectors and demands. The early preeminence of demands on rural environments for food and fiber production has been eroded by rapidly growing demands for recreation, second homes, retirement properties, and supplies of unpolluted resources of various types. Some of these demands are familiar and long-standing while others are new and exotic. What is more, new policies and concerns are propelling us further in this direction.

The growing national and state concerns for expanding urban agglomerations and for ways to upgrade the quality of life add a new dimension. Also, at the national and state levels, we have increased concern about improving our rural-urban population balance. The broad and continued concern for enhanced rural development and for regional (multicounty) development are important added dimensions. These several factors and others add to give major potential nonagricultural demands for rural quality and rural resources.

This paper focuses first upon nonmetropolitan environments or regions and some important considerations in their definition and delineation. Then it briefly reviews past trends concerning nonagricultural demands and some effects of policies concerning urban life, rural-urban balance, and rural development. It highlights some of the resulting issues and raises some challenges for policy makers and for professional economists. It suggests to the American Economics Association and to the American Agricultural Economics Association some specific reassessments of emphases and approaches.

Rural Environments or Regions

This is the first of three papers on "New Economic Roles for Rural Environment."[1] I would be remiss if I did not set the stage by reviewing some of the important considerations in defining and identifying "rural environments." I have deliberately used the plural "environments," for my experiences in resource economies and in area and regional economic analyses and action convince me that there are in fact many distinctly different though interrelated environments within the overall category called "rural environment."[2]

I shall treat first the matter of rural environments by focusing upon "environment." It is probably an understatement to say there is confusion about the meaning of environment.

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[1] My personal preference would be to focus instead upon nonmetropolitan environments rather than upon rural environments as requested by those organizing this session.

[2] There are many organizational and operational gains from identifying and using meaningful subsets of the rural or nonmetropolitan environment for analytical and educational purposes and for other public-private actions.

Environment—what definition

The first point to be stressed is that the term environment can be and is defined differently by different persons and different professions. It is fair to say that the majority of the writers on environment today focus upon one or more *natural resource situations*, such as inland and ocean waters, air, land, forests, flora and fauna, and our fund of mineral and fuel resources. They also focus upon wilderness areas, parks, open spaces, scenic areas and vistas, and other attributes of our natural resource situations. The identification, inventory, monitoring, use, abuse, protection, and restoration of these natural resources occupy the lion's share of the environmental arena.

There are a number of others who also are concerned about the *man-made resource situations*. The environments provided by towns and cities, the factories and commercial structures, the schools, the homes, the hospitals and nursing homes, the highway and other transportation networks, and the utilities are but a few. We build and use these man-made components of the environment daily. They constitute an important part of the total environment and are intimately interrelated with the natural resource situations.

There is still a broader view of the environment. It holds that the environment of man encompasses *physical* (natural and man-made resources), *economic*, *social*, *cultural*, and *aesthetic situations* and that these are interrelated. Further, this view holds that environmental problems are truly pan-disciplinary in nature and that analyses and solutions to those problems likewise must be pan-disciplinary in character. For an environmental improvement to be effective, it likely will need to be physically possible, economically feasible, and socially and culturally acceptable.[3]

I have found this broad view of the environment and environmental problems to be both functional and meaningful for environmental education and environmental action. A new institution (which I helped to build), The University of Wisconsin-Green Bay, has designed its entire academic plan, including instruction, applied analyses, and community outreach, around this broad conception of the environment [13, pp. 89–113].

Many different environments

The second point I want to stress is that while the world is one interrelated environmental system, it is both possible and necessary to identify meaningful and workable subsets of it and to talk about the various environmental situations outside our large urban agglomerations.

One can identify different rural environments, different rural-urban environments, or different nonmetropolitan environments and focus upon the nature and extent of their differences in problems and opportunities. One can refer to these different environments as "regions" or "environmental regions."[4]

Identifying meaningful regions

A third point to stress is that in identifying an environmental region one should not stop with physical homogeneity or simply with natural resource ties. The various other ties or linkages such as economic functions, communications, recreation, transportation, and education, as well as other social and other cultural ties, are all meaningful components of an environmental region [12]. These ties do not respect physical resource boundaries. However, they are exceedingly important as one focuses upon an environment that provides a higher quality of life and particularly important when one is concerned about the alternative feasible courses of remedial or other public and private action required to provide an improved quality of life.

Identifying a region in this manner gives one a functional economic and social framework within which to attack a wide range of environmental problems. And it gives a region that has cohesiveness and strength well beyond its economic and social ties.

[3] Land or resource economists for many years have recognized the necessity for physical or engineering feasibility, economic feasibility, and institutional feasibility, the last of these encompassing laws, regulations, organizational arrangements, and other group actions in control of individual action. For examples, see works by R. Barlowe, E. Castle, J. Frey, J. Muehlbeier, R. Penn, P. Raup, R. Renne, L. Salter, A. Schmid, S. Smith, H. Steele, J. Timmons, and C. Wantrup.

[4] The regions may differ distinctly in both their natural resource and their man-made resource bases. They may also differ in their economic base, e.g., farming, forestry, and recreation. They may have similar natural resource situations but different economic roles, e.g., recreation versus retirement area. They may differ in their social and cultural base and their aesthetic attributes. They may differ greatly in their ties and orientation with urban centers or large metropolitan or megalopolitan areas.

Importance of regions

As a fourth point, a region or regional setting is indispensable for environmental analyses and development of strategies for public action. It is clearly useful in analyzing the nature and strength of current nonagricultural demands for rural resources and rural quality. National perspectives simply do not convey the nature, magnitude, or urgency of such demands in regional settings. Regional approaches also are useful in making manageable predictions of future trends in nonagricultural demands for rural resources and rural quality and are clearly indispensable in creating plans and priorities for meeting these nonagricultural demands.

Federal and state laws and regulations now place emphasis upon the identification and use of regions for planning and developmental purposes. Further, my own research and that of fellow economists [3] indicate that a number of opportunities for simultaneously achieving economic improvement and environmental quality improvement are lost unless these are analyzed at the regional level as well as locally and nationally.

Emerging role of multicounty region

Colleagues of mine in government, industry, and colleges and universities are finding more and more that the meaningful subsets for environmental quality analyses, improvement, maintenance, and other actions are multicounty in nature. Such units usually have an urban center or centers and are comprised of many municipalities and small governmental entities. They cover various geographic configurations and do not respect state boundaries.

We have in the past year created in Wisconsin eight multicounty administrative districts.[5] They range in size from 7 to 11 counties and provide a regional framework for analysis and development of strategies covering both natural and man-made resources, as well as other economic, social, and cultural ties and features that affect the quality of human life [12].

I shall briefly review some trends in the nonagricultural demands for rural environments. Some demands have been for natural resources, particularly evidenced in changing land and related water use, and some for the aesthetic and rural life qualities, not necessarily reflected through physical changes in land and related water use.

[5] *Uniform System of State Districts*, Wisconsin Executive Order No. 22, Office of the Governor, August 24, 1970.

Some Trends in Nonagricultural Demands for Rural Resources

Natural resource demands

The 2.3 billion acres of land resources of the 50 states vary considerably from one part of the country to another in terrain, soil, and climatic conditions. The same can be said of the 1.9 billion acres of our 48 contiguous states. The uses and the use changes in these land resources also vary considerably.[6]

At the national level we see several major changes in land use. First, the amount of land needed to provide food, clothing, and shelter for the average American is decreasing. For example, the amount of land used for agricultural crop production has been decreasing on a nationwide basis. From 1950 to 1970 there has been an estimated net reduction of 37 million acres of cropland in the 48 contiguous states, or an average of 1.9 million acres a year. While the decrease is nationwide, the change varies by region. In some regions cropland has remained stable or has increased; in others it has clearly decreased.[7]

Second, we see a continued shift of land into nonagricultural uses, both urban and rural nonfarm. Such shifts of land to noncrop uses have been prominent in the Northeast, the Appalachian states, and the Southeastern and Southern Plains states. Some of these changes resulted from low productivity soils; from small, rough and isolated fields; and from limited moisture. Others resulted from demands for various urban and transportation uses, nonfarm residences, recreation, and other nonfarm public and private uses. These shifts have been particularly prominent along the eastern seaboard and near rapidly growing metropolitan areas elsewhere in the country.

Nationally we expect little change in the amount of grassland and pasture.[8] Forest land

[6] The Natural Resource Economics Division in the Economic Research Service of USDA continues to provide excellent statistics and evaluations on land and water resource use and change [2].

[7] During the 20 years from 1944 to 1964 about 54 million acres in some regions were changed to noncrop uses, while some 27 million acres of new land in other regions were changed to crop use. Cropland accounts for 23 percent of our land resources.

[8] Grassland and pasture ranges occupy about one-third of the area in the 48 states and is expected to continue at about that level through 1980 [2, p. 208].

and woodlands have increased slightly over recent decades. The acreage is projected to increase only slightly during the next decade.[9] Substantial acreages of noncommercial forests in the West and Southwest have been cleared or reclassified to other uses. Acreages of commercial forests have increased in the South and East.

Third, even though the national trends in net land use changes seem slight or moderate, they mask major changes occurring in small multicounty regions.[10] One need only visit from time to time the areas adjacent to Baltimore, Washington, Chicago, Minneapolis, Denver, and the San Francisco Bay area to see the enormity of changes in the counties adjacent to them. Or in my own state, Wisconsin, one can see major land use changes in Southeast Wisconsin near Milwaukee, in Southern Wisconsin near Madison, and in Northeast Wisconsin near the Fox River Valley cities and Green Bay.

Fourth, besides the shift of land to intensive urban uses, there has been a shift of land to extensive nonagricultural uses as well. The increasing demand for parks, recreation areas, wildlife areas, and other public areas and facilities is causing land use shifts to these uses. Together the land use shifts for these intensive and extensive uses are projected to be 14 million in this decade, or about one and one-half million acres per year.[11] Again, one must be aware that the shifts within a multicounty region can be major. That national figures show that we have land in the aggregate for all our domestic needs is of little consequence to small multicounty regions that are experiencing major land use changes which governmental units cannot adequately plan or guide.

Fifth, as we look at the new products and new services demanded in nonmetropolitan areas, we see only part of this demand reflected in statistics of land use changes. All manner of residential sites are being demanded, extending from opportunities for dense residential development near an urban center to scattered residential use, full-time and part-time, at great distances from urban centers. All manner of residential-recreational sites are being demanded, ranging from a lovely home on a lake, seashore, or scenic overlook to the most primitive cottage or place to pitch one's tent or park one's camper during the summer or other seasons. Near urbanizing areas all manner of business, commercial, industrial, and service facility sites are being demanded, including places for shopping centers, processing and manufacturing plants and parking areas, storage and distribution facilities and terminals, schools and playgrounds, police and fire stations, hospitals and clinics, and service centers for other public and private services. All manner of public recreation facilities and services are being demanded, ranging from large multiple purpose parks and forests to more specialized facilities such as playgrounds, beaches, public lakes and streams, wildlife refuges and areas, wilderness areas, scenic highways and trails, scenic overlooks, public campgrounds, and picnic areas. All manner of private recreation facilities and services also are being demanded for fishing, hunting, swimming, camping, hiking, horseback riding, skiing, picnicking, skating, relaxing in privacy, or enioying a vacation on a farm. Also being demanded are sites for our improved transportation networks; namely, the interstate and state trunk highways, the service plazas, the automobile and truck terminals, the motel and restaurant services, as well as the new and expanded air terminals and supporting services.

It may sound to you as if I have enumerated every possible demand in sight. Quite the contrary, this is but a part of the array of old and new products and services being demanded in our nonmetropolitan areas.

Notice that I have said nothing about the array of demands placed upon nonmetropolitan areas to receive the enormous waste created in metropolitan areas. These wastes are equivalent to the total input of goods going into the metropolitan areas and come forth as solid, liquid or airborne wastes [4, p. 8].

One could also focus upon the water supply [9] and show how the nonmetropolitan area has had to meet increasing demands from the metropolitan areas. Many of the demands for sites and services discussed above are in fact demands for land and associated water. The

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[9] Forest land and woodlands occupy slightly more than 30 percent of our land area in the 48 states. Regional shifts have been significant [2, p. 208].

[10] The shift of land into intensive urban uses has been increasing gradually, with about 3 percent of our land now devoted to intensive urban and transportation uses. About 58 million acres are now in intensive urban and transportation uses, and the amount will probably reach 65 million acres by 1980 [2, p. 208].

[11] About 85 million acres are presently in these extensive special uses, projected to be 92 million acres by 1980 [2, p. 208].

examples would differ in some instances, e.g., water for hydroelectric power, waste dilution, navigation, habitat for fish and wildlife, water-based recreation, municipal water supplies, industrial processing, and nuclear generating plant cooling.

Since the United States population is expected to increase about 15 percent by 1980 and may increase as much as 50 to 100 million people by the year 2000, we can be absolutely certain that the amount of resources demanded will also increase. Since there is every indication that the population increases will concentrate in the metropolitan and megalopolitan areas, this increased demand will have its origin in the metropolitan areas and will have its impact in the nonmetropolitan areas, namely ,the rural environments. In short, more people will demand more resources, And, if real income per capita increases as expected, if leisure time and mobility increase as well, and if more and more families adopt life styles that include a second and third home and new undreamed of conveniences, our shifting demands for resources will be even more accentuated.

As Marion Clawson of RFF points out, there also are some counterforces that serve to diminish the need for natural resources, at least relative to the growth in GNP: (1) Increasingly our total national output is made up of services of many kinds, rather than goods; (2) the efficiency of natural resource use has risen; (3) the average unit of natural resources is processed today to a far greater degree than a generation ago. While these counterforces will continue, they will temper but not offset the increased demand resulting from our growing population, higher per capita real incomes, and more consumptive life styles [1 pp. 338–339].

Dr. Clawson and his colleagues conclude that for the foreseeable future the material well-being of the American people will not be jeopardized by absolute scarcities or seriously rising prices of raw materials. They point out, as I have earlier, that there will be problems of providing enough natural resources of the kinds sought, in the time and place demanded, at what seem to be reasonable prices [1, p. 339].

Demands for quality

More serious, however, will be the demands for quality in the available natural resources. It appears that people are going to demand higher quality in their available natural resources. Nonmetropolitan areas are going to be asked, or demanded, to provide water for recreation that is less contaminated, runoff that is less polluted, air that is less befouled, parks that are less littered, roadways that are less cluttered, lakeshores that are less unsightly, forest areas that do not show the scars of clear cutting; and wilderness areas that are protected from overuse.

The same beliefs and values that give us growing population and a desire for more conveniences, comforts, and consumption, or more and better quality goods and services simultaneously give us more waste residuals that take the forms of air, water, or solid wastes. The wastes must be absorbed, and in large measure in the nonmetropolitan areas.

The rural environments must now also provide opportunities for social, cultural, aesthetic, educational, and scientific enrichment of our urban populace as well. Rather than giving you hypothetical examples, I have gleaned the following actual examples from the local news media during a one-month period: Use of 1,400 acres of county forest for scientific purposes, to determine the effects of nuclear gamma rays on trees and plant life; demands for preservation of the lands and cultural heritage of Menominee County for the Menominee Indians and others; proposal for a residential-recreation complex for special recreation, aesthetics, and social benefits to potential occupants; demands for preservation of the scenic Wolf River in its wild state; pleas for building recreation-residential units on artificial lakes to provide a restful and aesthetic setting; demands for a new interstate highway and differences of opinion between highway engineers and ecologists over route locations; plans for possible use of geologic formations of Northern Wisconsin for a low-frequency communication system with an extensive underground antenna grid. There were of course many more articles that treated the demand for resources and resource quality in rural environments and many articles on the matter of waste residuals that must be absorbed by rural environments.

I have made the case that our nonmetropolitan areas will be required to produce a different array of outputs beyond those customarily provided by the agricultural sector. I have done this by reviewing activities with little reference to possible changes in national and state policies that bear directly upon the new roles for rural environments.

Possible Nonagricultural Demands from Emerging Policies

Policies concerning urban life and improved rural-urban balance

Various agencies and groups at the federal and state levels have become concerned with the quality of urban life, or the quality of life and living in urban areas. Early concern for the slums plus later concern for other forms of blight, crowding, noise, filth and litter, automobile and other traffic congestion, and air pollution have given rise to reassessment of some of our programs concerning urban growth. It should be clear to even the casual observer, however, that our nation and our states have lacked clear-cut policies concerning quality of urban life and the massing of people in metropolitan and megalopolitan areas.

Concern has led to a great many federal programs, in fact, to catalogs of programs for federal domestic assistance to states, communities, groups, and individuals. Concern has also led to creation of the Rural Affairs Council and the Urban Affairs Council and their subsequent consolidation into a Domestic Affairs Council at the federal level, with a keen interest in rural-urban balance.

Interest in more balanced growth to affect positively the quality of life in urban and rural areas has led to various proposed strategies or policies. One of these is to retain population in sparsely settled areas and to spread population to sparsely settled areas by generating economic growth there. A second is to deliberately foster growth of smaller cities and towns in nonmetropolitan areas, whether individually or in some grouping. A third is to create new cities outside metropolitan regions [6, pp. 39–61].

Interest in improved rural-urban balance also has given rise to new efforts by governors. In my own state it led to the creation of a Mission 70 process in the spring of 1970, an effort on the part of Governor Warren P. Knowles to bring more orderly and balanced development to Wisconsin. He and others recognized that at the same time that Wisconsin's smaller rural communities and rural areas were suffering from declining human and economic resources population growth in certain urban areas threatened to strain the resources of the cities beyond endurance [5]. Since I was a member of the statewide Mission 70 Council and chairman for a regional inquiry into problems, policies, and possible programs for the Northeast Wisconsin region, I have some first-hand observations to share with you.

This inquiry [11] disclosed that in the multicounty region of Northeast Wisconsin the most urgent problem was insufficient employment opportunities to maintain current populations and provide a viable base for improved state rural-urban balance, and the second most urgent problem was deterioration of the surrounding environment. Further, the inquiry showed that the decisions made about increased employment and the decisions made about environmental quality improvement were not interrelated, although actual effects of the two are closely interrelated.

It was clear also that some rural areas do not have the type of services and facilities needed in order to absorb increased populations and that many rural areas do not have the quality of services that their current residents require. Therefore, if a policy of improved rural-urban balance is to be pursued in Wisconsin, the nonmetropolitan regions must provide economic opportunities, an improved level of services, and a quality of environmental amenities that will attract new residents from the metropolitan areas. If a policy of improved rural-urban balance is implemented, it probably would accentuate materially the nonagricultural demands placed upon rural environments today.

Policies concerning rural development

For many years the federal, state, and county governments, as well as our land-grant colleges and their experiment stations and extension services, have fostered rural development. This continuing effort had its origin in ideas of the 1930's and received impetus in the 1950's and early 1960's from USDA's Rural Development Program and the subsequent Rural Area Development Program. Interest and activity in rural development has continued, with increased attention being given to multicounty approaches. While we have had multicounty areas for use in collecting agricultural and other statistics for many years, the use of such areas for assessing problems, identifying opportunities, and planning development activities is quite recent. The Resource Conservation and Development Districts developed under the sponsorship of USDA are prime examples of the recent efforts.

Federal and state agencies in addition to those concerned with agriculture have developed multicounty approaches to planning and action that foster rural development, Notable

among those created under federal programs are the Economic Development Districts and their counterparts in Appalachia called Local Development Districts. States also are creating uniform state administrative districts on a multicounty basis, and federal agency districts are being adjusted to become coterminous with the state districts. These and other governmental efforts are fostering rural development.

The multicounty districts for development hold some promise for enhancement of rural areas through new and better income and employment opportunities and through improved and more efficient public services. They hold promise in retarding the growth of megalopolitan and metropolitan areas as they enhance the identification and implementation of new income and service opportunities outside [3].

As rural development policies and processes are implemented, they too accentuate the nonagricultural demands placed upon rural environments today. One need only look at rural development efforts in recreation to see the array of new public and private recreation facilities and services created. These new recreation facilities and services require different uses of land, labor, capital, and management than previously required in our rural environments. Even agriculturally related businesses, such as food processing firms, result in new demands for rural resources and rural quality.

Issues and Challenges

Some key issues

A number of issues and challenges have been indicated by the trends and policies just reviewed. Here are a few of the issues.

First, we observed that the rural environments will be required to produce an increasingly different array of outputs than in the past; that the output of agricultural products and services will be challenged more and more by demands for nonagricultural products and services. One of the key issues will be whether the production challenges presented by the new demands can be met. Can land, labor, and capital be mobilized to meet these new demands? Can the management and control of these resources be aided in being responsive to these new demands?

Second, the quality requirements of the new and growing demands are inconsistent with the increased quantity of physical resources required by these demands. A key issue will be whether we can raise for searching reexamination and possible modification the beliefs and values about life style that include increasing population, increasing consumption, and limited concern for the side effects.

Third, these new and growing demands are a new breed. The demands for rural resources and rural quality are not necessarily contiguous to the metropolitan or megalopolitan areas from which they emanate, but can jump from a few miles to great distances. The specific demands differ widely in their predictability.[12] They are both market and nonmarket in character, and some of the most directive in terms of resource use changes are nonmarket. Further, the demands are very iffy. They are heavily contingent upon values and attitudes of people about consumption, upon population growth, and upon national and state policies and programs concerning rural-urban balance and rural development. One of the key issues here is whether we can cope analytically and operationally with the identification and prediction of these demands. A related issue is whether we can translate those predictions into meaningful plans and actions for servicing the demands.

Fourth, national and state concerns for retarding the growth of megalopolitan areas and for retaining current populations in less sparsely settled areas clearly require economic and social development of the nonmetropolitan areas. Such concerns require also a consistency of purpose in various federal and state policies and programs beyond what has been achieved in the past. One key issue here is whether we can deliberately develop in tandem policies and programs at the national and state levels with consistency of purpose in land settlement; in economic development; in environmental improvement; in transportation; in health, education and welfare; and in rural development. A related issue is whether these can be translated into meaningful substate plans that at the same time involve substate areas in decisions about their destiny.

Fifth, if nonmetropolitan areas or rural environments are to meet growing demands from urban areas and at the same time help bring about an "improved rural-urban balance," the leaders and citizens must develop some clear goals or targets. We have a massive arsenal of federal, state, and local programs and agencies

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[12] One need only consider the difficulty in predicting demands for improved quality of water runoff, for cleaner lakes for swimming, for recreation-residential home sites on artificial lakes, and for lands for scientific use to sense the complexities involved.

and manpower for economic and social improvements. However, we are woefully lacking in visible targets. Thus, another key issue is whether we can develop functional economic and social developmental targets toward which joint public and private efforts can be efficiently directed and coordinated. While targets are needed at the various governmental levels, they are indispensable for efficient action at the multicounty level, as are professional staff,[13] funds, and analyses.[14]

Added challenges for economists and our associations

A number of challenges for economists and our associations are clearly implied in these issues and will not be repeated here. In addition. we must give much more attention to the economics of a closed environmental system and to meaningful subsystems. We should openly and widely raise and discuss the consequences of our fixation upon the amount of throughput from the factors of production to consumption —our chief measure being GNP.[15] We must evaluate the likely side effects of a larger and larger throughput on the quality and character of individual lives and its likely differential impacts on resources and regions. We must determine ways in which decisions about economic development can be integrated with decisions about environmental improvement, both in the public and in the private sectors. We must evaluate the current and emerging beliefs and values and their consequences for our future and at the same time assess credible alternative beliefs and values and their likely results. We must determine the specific amenities, qualities, and features that people prefer in large urban areas and sparsely settled rural areas and ways of providing these at different population sizes and configurations [8]. We must become more deeply involved in identifying possible economic and social development targets at the multicounty regional level and must design economic and social indicators to improve public and private decision making about targets and progress toward them [7, 10].

Neither economists nor associations can remain simply with their "own kind" and expect to make major impacts on any of these problems. Concerns for rural environments, rural-urban balance, urban and rural amenities, consequences of beliefs and values, economic and social development targets, design of economic and social indicators, and other matters go well beyond economics. The problems are pan-disciplinary in nature, and analyses related to them must also be pan-disciplinary to be thorough. Thus, the economist must deliberately identify problems and design and conduct analyses with members of other disciplines. The economist must also involve those leaders who are confronted with decisions about the rural environments. If we are to contribute something truly meaningful, the walls surrounding our economics and agricultural economics disciplines must come down. If we are to make contributions that are indeed used, walls between the professional economist and decision makers in our communities and regions must come down too.

[13] Not only will the nonagricultural demands confronting a multicounty region differ, as will the economic and social development possibilities, but the region's professional and financial capabilities for planning and action will differ also. Another important issue is whether federal and state governments will provide the technical and financial resources needed to permit these multicounty units to organize, staff, conduct ongoing analyses, develop and update plans, and monitor progress and effectiveness. The Bureau of the Budget directives that specified creation of regional clearinghouses to evaluate federal grant, aid, and loan proposals did not provide a procedure for staffing and financing those clearinghouses.

[14] A colleague, James Murray, is estimating possible per unit cost savings for public services that might be achieved by rural counties and communities through increased population size. Such analyses are fundamental to estimation of current economic benefits that can accrue to the public sector from the addition of population to some less-populated areas.

[15] Even the use of the measure needs a searching re-examination. For example, we have adjusted GNP to measure its growth without inflation. We have adjusted GNP to show it has not grown at the rate it could have, yielding a GNP gap. However, we have not evaluated GNP and its side effects to show the disinvestment in the resource base resulting from different levels and compositions of GNP.

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Future Use of Rural Resources*

L. T. Wallace

WHAT DO THE emerging patterns of U. S. production and consumption imply for the use and management of rural resources? To what signals should rural resource allocation decision makers respond? Increased population, the broadening demands of an affluent citizenry, reduced time constraints, extended possibilities for factor substitution, and ever closer ties between urban and rural interests have intensified pressures on rural resources for other than agricultural use. Increasingly, contemporary life styles entail increases in the demand for rural amenities, a desire to modify production processes in order to sustain or "renew" a high-quality natural environment, and a concern that those with low incomes not be denied access to a reasonable quality of life.

Many people, concerned about the nation's productive processes and their impact on the physical and social environment, have involved themselves in transforming rural resources. While we do not yet know the full dimensions of this transformation, it is clear that comparing values determined by capitalized product and factor rents, annual income streams, and imperfectly competitive governmental resource use permits is no longer a theoretically unassailable way for determining what use of a resource yields the "highest and best use."

Preservation and conservation interests are challenging with increasing success the underlying logic by which rural resources have been organized only for food and fiber production. Absolute increases in demands for extractive commodities (food, fiber, minerals, lumber, etc.) vie for rural resources with increases in demands for nonextractive uses. National agricultural policy finds increasing fragmentation within the organized agricultural interest groups. Rural development, while an agenda item of most domestic departments of the Federal Government, still has trouble identifying the critical issues in the population-resource balance of rural communities to permit rational regional economic development efforts.

Economic, social, and political dynamics strongly suggest that the ground rules for using rural resources in the future will be different. The profession of agricultural economics has an opportunity to help clarify these rules and to develop new criteria for public policy pertaining to rural resource use.

New Patterns of Rural Resource Use

There is substantial evidence that both absolute and relative shifts have occurred in the demand for rural sector goods and services. Transportation has reduced the time factor bringing all nonmetropolitan areas closer to urban centers; employment opportunities creep outward into urban centers and satellites; land development leap-frogs in an effort to bring cheap housing and recreation to employees located in urban centers; and ultimately, the areas closest to population concentrations get swallowed (albeit under conditions of economic rationality) and become launching pads for increased "opportunities" for development.

The size and form of population concentration helps to explain part of the rural resource pressures. Rapid urbanization is the dominant trend. From 1960 to 1970 the population in nonmetropolitan areas grew about 4.6 percent compared to about 18 percent for metropolitan areas [5]. The merging of metropolitan areas allows no relief from urban resource use intensity and results in scale problems of waste management. With over 70 percent of our population concentrated on slightly over one percent of our land, it seems inevitable that sheer quantity of use cannot hope to maintain the original threshold of resource quality. It also seems inevitable that with deteriorating quality of urban resources, rejuvenation is sought in outlying areas.

Some rural counties have sustained several decades of persistent outmigration. About 1,500, or half of the counties had fewer people in 1970 than in 1960. Farm population dropped about one-third, or about 4.5 million people, during the 1960's [1]. Nonfarm people in non-

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metropolitan areas increased about 16 percent or about seven million people, in the same period. The growth in nonfarm nonmetropolitan population plus persistent outmigration data from agricultural and mining counties suggest expanding rings of population surrounding the goods and services employment-rich metropolitan centers [2].

Urban-to-rural migration is another factor in the growth of the nonmetropolitan rings surrounding metropolitan areas. Almost a quarter of the "ring" residents were of urban childhood origin [1]. This group has a lower poverty incidence than the rural people, more sophisticated jobs, and a higher educational attainment level [4]. However, by and large, nonmetropolitan areas still have lower per capita incomes than the metropolitan areas, less education, fewer services, and fewer cultural attractions [8, 7].

Since 1950 population has increased 34 percent; but electric energy production has increased 300 percent, natural gas usage has risen about 250 percent, crude petroleum usage is up about 100 percent, and the number of cars and trucks has more than doubled [1]. Our standard of living has enabled us to consume more resources at a faster rate than ever before. It seems quite natural that some people are asking: Consumption for what ends? Can our society slow resource use and maintain itself? What are the current and predicted relationships between growth, stability, consumption and equity? How can coordination between uniquely endowed regions be accomplished?

While the relationships among demand shifts, production activities, social welfare, and resource allocation operate reasonably well within appropriately competitive product and factor markets, there are good reasons for expecting that current demand dynamics for rural resources will not be translated into socially efficient allocation patterns without some policy intervention. These reasons include: (a) difficulty in specifying the social demand or utility functions; (b) poorly understood technologies for producing certain types of rural services; (c) obscurity of the total costs of production; (d) institutional obstacles to human mobility; (e) policy constraints upon production possibilities. Each of these is discussed briefly.

Specifying relevant demand functions

There are many reasons for confusion about the signals to which organized rural sector production activities respond. First is the question of what is really being demanded. We used to know, intuitively at least, what rural community utility functions were and how to maximize them. Now the population pressures and other factors mentioned above have extended the conventional parameters. This is especially true considering the increasing national sensitivity to the aesthetic and other qualitative dimensions of rural resources.

However, demand functions presumably measure willingness and ability to pay for what is wanted. While it may be possible to estimate demand functions for different recreational environmental qualities (i.e., demand functions for different recreational environments may be synthesized from visitor-participation data), what is a community's "willingness to pay" to obtain a certain level of dissolved oxygen in its rivers and streams as opposed to some lower level?

A related problem that obscures allocation signals is the lack of traditional markets for many of the new environmental services desired from the rural sector. As a consequence, we do not have explicit information about quantities transacted at different price levels. The possibility exists that a current market price efficient decision can quickly become inefficient if a time lag is encountered in the adoption of technology or institutional persuasiveness, if social values change, or if new knowledge is provided. Current market price decisions perhaps favor short-run extractive industry interests more than the preservationist point of view. It might be difficult not to get frozen into an untenable resource use situation on the basis of incompletely revealed preferences or poorly defined shadow pricing.

The importance of collective goods and services in the rural sector raises additional problems relating to specifying demands for rural resources. From the standpoint of an individual, environmental quality or its lack is characterized by economic externalities. Partially in response to this the unit purchasing the bulk of these goods and services has tended to be governmental, a county, state, or region. The problem of efficiently encompassing individual preferences into some form of community demand function thus becomes extremely important, if we are to discover what communities really are willing to pay for these qualitative goods and services. Some mechanism that provides information about production possibili-

ties and permits trade-offs among individuals with different value rankings becomes an important ingredient for actually articulating demand. If the growing national interest in the amenities of the rural environment truly reflects a willingness to pay, this area warrants high priority research efforts.

Poorly understood production technologies

While the production technologies of food and fiber are relatively well understood, we appear to have few equivalent resource-response data regarding the production of amenity goods and services derived from rural resources. For example, we have been operating largely on the assumption that a recreational enterprise simply provides a number of fundamental facilities, such as access, parking, and sanitary facilities, at not "too high a price." As recreational consumers have become more articulate, a demand has emerged for different types of recreational opportunity which often are mutually exclusive. Yet our notions about alternative ways of producing these services are as primitive as our notions about "maintaining the quality of our environment." For example, is a wilderness experience identified only by low density of use; are there land management programs capable of producing a "real" wilderness experience (or one that has sufficiently high "quality" to satisfy the demands of a particular wilderness constituency)?

Another example: What are the land management measures for scenic highways which must complement the structural engineering to produce the desired "product" (assuming the highway should be built at all)? In mountainous areas, are all timber harvesting measures to be ruled out, should timber be clear cut to offer "enhanced viewpoints," or should some compromise growth-harvest-view policies be determined? The cost of road investments and the willingness of private landowners to participate will be highly sensitive to the answer.

As the rural areas of the United States are increasingly sought for residential or second-home purposes, the production functions (as well as the goals) for community and social services become increasingly important, multivariate, and complex. History has provided us much empirical information regarding services such as water supply, sewerage, and electricity; however, often these supply systems were organized for relatively small, year-round agricultural communities and did not take full advantage of contemporary production techniques. With increasing recognition that some of the older patterns of rural area settlement are cost inefficient, new production techniques become extremely important. Indeed, what economies of scale considerations in providing public services should be taken into account when determining the population settlement patterns we wish for the future, as well as the organization and financing of local governments once established?

The obscurity of production cost

A third reason why the evolving array of demand on rural sector resources is not automatically translated into efficient allocation patterns is that the full costs of production activities often are not incident upon the entrepreneur. Much has been made of the external costs imposed by the leftovers or residuals from extractive production activities. To these concealed and sometimes publicly subsidized "costs of production," should be added similarly subsidized "costs of consumption" when residual energy and materials from consumption must be disposed of into the environment. Under current policies and procedures, when these externalities costs are not borne by the producer or immediate consumer, relevant prices and costs may not be used when performing conventional economic analyses of calculating contract isoclines, cost and revenue curves, values of marginal products, opportunity costs, and other benefits and costs.

Failure to account for full production costs often introduces a systematic bias in rural resource allocation decisions. This is especially liable to occur between extractive uses and preservation uses. Usually preservation uses have few if any external costs, while those of extractive activities can be substantial. One hopes, as environmental protection policies are introduced to internalize these external costs, that efficient allocation decisions will result. It is an open question whether one can clearly count on the enactment of such policies or whether specific policies for rural resource allocation should be introduced that compensate for the biases of today's private enterprise bargaining process.

Obstacles to factor and human mobility

Fixity of capital discourages factor mobility and thereby directly reduces medium- to long-run efficiencies of resource allocation. Yet many

current programs, such as Farmer's Home Administration water and sewer grants, encourage indiscriminate fixity of social overhead capital in communities where, despite subsidies, per capita costs of public services remain high, services continue on a limited scale, and quality of service often remains low.

Future capital needs may be toward greater liquidity concentrated within a specific geographic area. People deciding this capital allocation must confront the political unpleasantness that all geographic areas need not be treated equally by public agencies, since differing resource endowments entail differing marginal social products and payoffs.

One question we must face is whether, with limited national resources, all of the country's villages, towns, and cities have equal right to call on the nation's budget without some corresponding move towards establishing a more economically viable concentration of people. Perhaps it would be kinder in the long run to let some communities die while others are encouraged to grow, subsidizing the move for residents who want to move to places of agreed-on population concentration.

In essence the population problem is also a job location problem, affected by all of the economic and noneconomic factors that affect industrial and service employment. Overall policies providing access to education, housing credit, and transportation considerations may be first priority "enabling employment" tools, but they are seldom "job providing." Employment opportunities still seem to follow the rule that the richest areas get richer, a pattern that has not changed much during the last decade despite efforts to alter it.

Poverty includes more people in rural areas than in the urban areas, and because of its relatively high rural incidence there is need for certain services to be provided outside of regular market channels [4, 6, 7]. The infrastructure of state services must be relevant to the current needs of people. For example, job information could be circulated within a region and job applications solicited without causing the job hunter to take a long and sometimes expensive trip to no avail. Use of computer facilities could quicken the screening of applicants and hasten job notification in much the same way airlines now check for available seating at time of reservation.

Perhaps the concept of "bundle of rights" associated with proprietary interests and the control of rural resources might also be reexamined with a view to possibly separating certain of the property rights from the bundle. The rationing of rural resources or access to them and progressive price discrimination by public agencies are policy alternatives to fee simple purchase for achieving changes in real income distribution which directly challenge the ownership thesis of the bundle. Master plans and zoning ordinances have been proven time and again to be ineffective and weak public servants when opposed by a determined developer. When the community utility function in rural areas was perhaps more homogeneous and intuitively better understood thirty to fifty years ago than it is now, factor weights and values were well accepted in fairly evident production and consumption functions. However, with changing technology, evolving demands, and changing social values, a critical review of the proprietary aspects of rural resources would not seem inappropriate.

Constraints on policy alternatives

It is always difficult to identify and choose which policy or set of policies is most appropriate in a situation characterized by flux. Organizational-institutional arrangements for implementing and adjusting to changes in the evolving production-consumption mix bearing on rural resources have become increasingly complex. It is clear that we have not fully explored the jointly responsible ranges of complementarity between state, regional and local, public and private, controlling entities. However, the advent of more federal-state revenue sharing may permit experimental joint ventures with regional governances for the sake of efficient project conception and implementation.

Decisions concerning resources in nonmetropolitan areas are becoming dominated by metropolitan dwellers. Open space, recreation access, second home sites, green belt zoning, highway construction, and lack of explicit tax relief for rural resource owners are topics lending themselves to this domination. On the other hand, rural institutions often favor agriculture to the exclusion of multiple use concepts. Farmers, as price takers, feel thwarted when their resource control and incomes are threatened in the name of quality of environment, ecology, and equity by city residents who are independent of rural resources for their livelihood.

Local governance in rural areas sometimes is

unable to reconcile these conflicting viewpoints and institutional fragmentation. Preservation and enhancement of amenity resources meets head-on the need to create jobs and living spaces. Pressures from technology, from transportation, from international markets, from the factors affecting effective final demand, and from the derived demands for production and service inputs have put intensified pressures on all levels of institutional decision making.

While common themes run from federal to regional to local bodies or agencies of government, under our present social-political-economic system direct initiative control of resources at the community level is limited [3]. Primarily, one sees there a response to specific federal or state legislation. The continuum reduces degrees of freedom as the channel is traced from federal conception to regional and thence to community implementation. While much enabling legislation comes "down the Pike," its effectiveness is dependent on local initiative, interpretation, and understanding. This situation allows for urban suggestion, regional obstacles and hesitation, and rural enactment, with a resulting overview of confusion, lack of any goal attainment, and wasted resources.

An Applied Research Effort

Many California counties are on the fringe of rapidly urbanizing areas and are subject to increasing development pressures. Some county officials have been concerned about what "agriculture" is worth to their economy. Using input-output technique and both primary and secondary data, conservative estimates were obtained for ten agricultural sectors and nine other sectors.[1] These estimates provided a chance to evaluate several resource use options, thereby offering an educational opportunity for Extension personnel, county officials and interested citizens to discuss which course of action might be "best." A secondary educational objective was to provide county officials with the input-output tool (programs, data cards, etc.) using economists at the University for interpretation and help in determining resource policy.

A five-county region was defined north of the Bay Area and a separate set of tables constructed for each county. The first step was to estimate the basic dollar flow or transaction table, the technical coefficients table, and the inverse matrix for 1965. The second step was to make projections of these tables for a reasonable planning period of twenty years. The third step was to estimate the economic effects of selected but pertinent resource changes within the county.

In one county four simplified examples of different ways to use the county's resources were used to illustrate input-output as an aid to decision making. Each example was based on an actual unresolved resource use question in the county. The first example called for an estimate of the initial economic effects on the county's economy of a 20 percent decrease in the county's timber production due to fire; the second was to estimate the economic effects of planting 5,000 acres of wine grapes; the third was to estimate what the loss to the county would be of closing down the county-state hospital; and the fourth estimated the gross economic effects of establishing a 1,100-student junior college in the county.

The timber production loss amounted to a sales decrease of $8 million, expanding into a gross economic loss to the county of slightly over $22.5 million. Put another way, for every dollar of sales decrease the county lost an additional $1.81 of economic activity.

In order to plant 5,000 acres of wine grapes, 5,000 acres of hay had to come out of production. Annual sales attributable to the wine grapes were estimated at just over $1.5 million and resulted in a total increased economic activity of about $3.5 million. However, when the economic effect of the withdrawal of hay acreage was subtracted, the net effect of the wine grapes on the county's economy was about $2.8 million.

The budget for the hospital was about $12.4 million. An additional two dollars was generated for every dollar of expenditure, so that the total loss to the county if the hospital were to vanish was around $36.5 million. In part this estimate is so high because approximately 80 percent of the hospital budget is spent on salaries and wages that are consumed locally.

Data for the junior college example were taken from an operating budget ($1.2 million) of a similar school. Estimates were made of in-county and out-of-county students, whether they would room at school, and how much they might spend. When the effect of the college's

[1] At this time the preliminary manuscripts are being revised. More complete information will be published in the spring or fall of 1971.

operating budget ($3 million) is added to the effect of the student's expenditures ($2 million), the total gross effect in additional sales amounts to just over $5 million.

While the examples used were only estimates, the analyses were timely and provided local officials responsible for making decisions about land use, health facilities, and schools with quantitative resource information they had not had before. While much can be done to improve and modify the estimates, much has been gained too, since many county residents participated in gathering data which they considered to be important and in rendering judgments about them.

One important thing derived from this research-education effort was an analytical framework that local decision makers could use because it was both problem- and location-specific to them. The audience was ready. The need to study resource problems other than those concerned solely with commercial agriculture is evident. As economists, we can do much to help evaluate future rural resource development and use by offering timely and sometimes "imperfect" analytical information to private and public groups interested in enhancing nonmetropolitan America.

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Public Policies for Rural America: Legacies or Leading Edges?*

LYNN M. DAFT

THE AIMS of this paper are three-fold: first, to identify and briefly evaluate the performance of some major public programs having impact on what is generally considered rural America; then, to examine some of the key forces behind this performance; finally, to consider some implications for future policy making.

Programs and Performance

For the purposes of this paper I find it convenient to think in terms of three types of programs: (1) those that are specifically directed toward rural issues; (2) those that are essentially rural in character but are not explicitly limited to the rural setting; and (3) programs that have no particular geographic focus but have impacted in varying degrees on the rural population.

A large share of the public programs that relate most directly to rural people address needs of the agricultural sector. Many were enacted during an era in which the agricultural economy was depressed or threatening to become so. Agriculture and rural were nearly synonymous. In the early 1930's a large share of the total rural population was engaged in farming. Most of the remainder were indirectly linked to agriculture through employment in farm service, supply, and marketing activities. It is also noteworthy that responsibility for implementing a majority of these programs was lodged in a single federal agency, the U.S. Department of Agriculture.

In more recent years nonagricultural needs of rural areas have begun to attract the attention of public policy makers. Though these programs have not been limited exclusively to rural areas, their expenditures have been proportionately greater there as a result of program design. This list includes the Economic Development Administration projects; the Appalachian Regional Commission; Hill-Burton hospitals; the housing, water, and sewer programs of the Farmers Home Administration; the Department of Housing and Urban Development's nonmetropolitan comprehensive planning program; Corps of Engineers projects; the rural loan programs of the Economic Opportunity Act; and Small Business Administration programs.

Finally, there is a third and much larger set of programs which, while not expressly designed for rural needs, have had some impact upon the rural population. The list is far too long to detail here but includes such authorizations as Medicare and Medicaid, the Elementary and Secondary Education Program, the Interstate Highway System, Civil Rights, and Social Security.

The evaluation of public policy—even one small piece of one act—is no small task. If our experience with planning, programming and budgeting systems (PPBS) in the Federal Government has given us anything, it has been an even healthier respect for the complexities and hazards of meaningful program evaluation. But at the risk of oversimplifying I believe one can identify some overall forces at work within these programs that reflect on their performance.

First, the programs designed exclusively for rural needs have generally been preoccupied with the aims of improved production efficiency and economic adjustment of the firm and the industry. Program benefits have been linked principally to land and capital resources.

Second, these particular programs performed rather well. There is substantial agreement among students of the subject that the farm programs developed in the 1930's and continued in varying forms to the present day stabilized an inherently unstable agricultural economy and thereby contributed in some measure to the orderly growth of the overall national economy. Such policies had the additional side effect of stimulating the rate of adoption of new technology, thereby releasing resources, principally labor, for employment in other socially useful endeavors. Unfortunately, not all of these resources were in the appropriate form or place for nonfarm employment, and

* All views expressed in this paper are my own and should not be interpreted as the official policy of any federal agency. I would like to acknowledge the helpful comments of Michael Brewer, William Motes, and Derek Schoen.

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therefore many remained in an underemployed state.

Third, rural programs have not usually addressed needs of the individual or the community. Rural people with little or no holdings of land or capital were in substantial measure abandoned by public policy. We have evidenced through our policies a much greater willingness to intervene in commodity markets than in rural labor markets.

Finally, those programs designed to meet human resource and community needs have generally been delivered more effectively within urban than in rural settings. A recent locational analysis found that federal expenditures in fiscal year 1969 (adjusted for population) significantly favor central cities, the richest counties, the fastest growing counties, and the very large metropolitan areas (population in excess of 1 million) [9, p. 51]. Those categories for which rural areas received a proportionally larger share of program funds included agriculture, recreation, regional development, ground transportation, business and farm loan, and development loan programs. Those categories for which rural areas fared poorly (and exceedingly so in the first three) included vocational education and manpower training, housing loans, defense contracts, defense payrolls, and health services and care.

Policy-Making Determinants

What are some of the more important causal elements that underly this performance? Future improvements will depend on our ability to identify these determinants and to recast them. For the sake of convenience, I shall separate them into two sets: those that are in some way unique to the rural setting and those that transcend any particular sector and apply to the policy-making climate of the Federal Government in general.

Rural setting

"Rural" policies.— Some years ago Karl Fox observed,

> The major problem of rural society in the United States is our institutionalized belief that a rural society exists and can be manipulated successfully apart from society as a whole [4].

Unfortunately, many present-day policy makers still cling to this belief. Legislators and administrators continue to attempt to force programs into rural molds which they do not fit. To further complicate matters, the target populations of these programs rarely coincide. What one agency labels rural, another labels urban.

Although this may at first be dismissed as little more than a problem of semantics, I believe a more basic difference is involved. The "rural policy" approach is too frequently rooted in the past, in nostalgia, in what the world used to look like, and not in how it appears today or is likely to appear tomorrow.

Continuing to make this distinction in policy making leads to obvious dangers: (1) It attempts, by legislative or administrative edict, to establish arbitrary program boundaries; (2) it is grounded in a stereotype image of rural that fails to capture the diversity that exists in reality; and (3) it results in policies that are often more concerned with circumventing or delaying change than in accommodating it through realistic forms of adjustment.

Institutional advocacy.— In the late 1800's and early 1900's agriculture was the mainstay of the rural economy, indeed of the national economy itself for a time. It was not until the late 1800's that our nation's nonfarm population exceeded its farm population. During this era agricultural policy was rural policy, and vice versa. So it was that the Secretary of Agriculture, the farmers' representative at the Cabinet table, also became rural America's representative.

For a time this was a comfortable match. The programs for which the Department of Agriculture held operating responsibility generally addressed those issues of greatest significance and concern to rural Americans. Yet as agriculture's relative importance to the rural economy diminished, the correspondence of farm issues to rural issues faded. Price supports, supervised farm credit, and the multitude of other agriculturally related programs aided an increasingly smaller share of the rural population. Other issues—nonfarm job opportunities, health care, education, transportation—assumed greater relevancy.

Despite these changes in the rural sector's nature and needs, the Department of Agriculture has continued to serve as rural America's advocate in the Federal Government's councils. In some administrations this responsibility has been made explicit; in others it remained implicit, based more on custom than formal agreement.

The most frequently cited justifications for

the Department's continuing to play this role have been (a) its extensive network of personnel, offices, and working relationships throughout the nation and (b) its familiarity and identification with the needs and capabilities of rural people and institutions.

But these are no longer enough. The Department of Agriculture simply does not have sufficient control over the design and implementation of enough key programs to effect a unilaterally defined rural policy. Neither does any other single federal agency. This is an institutional reality that must be faced if policy and programs are to be brought into concert.

"Place" versus "people".— As noted above, many of the public policies impacting on rural areas have been attached to capital and land rather than labor. In part this can be traced to the nature of the agricultural supply problem. Policy makers were drawn to control of the land input in an effort to curtail farm production because it was more easily controlled than most other factors. In the nonfarm economy the reasons were more roundabout, yet the purpose was essentially the same: to protect fixed investments endangered by major economic disequilibrium. But regardless of the cause, the effect was to abandon much of the human adjustment problem to the dictates of the market economy.

Depressed area focus.— At the time regional development issues were placed on the national agenda in the 1960's conditions in the more economically lagging areas of the country were severely depressed. Not surprisingly, most of the efforts begun during this period— the Economic Development Administration, the regional commissions, and parts of the Economic Opportunity Act—sought to strike directly at those pockets of severest depression. In large measure the approach was curative rather than preventive. The Economic Development Administration pursued a "worst first" strategy for regional development.

There is mounting evidence of the general ineffectiveness of this approach. The economic and social forces underlying the areas' depressed conditions often proved to be of far greater strength and pervasiveness than anticipated.

The Appalachian Regional Commission has perhaps been more resourceful than its sister agencies in avoiding sinking large investments into areas of low growth potential. Still, the Appalachian region is itself defined by criteria representing economic depression. The Economic Development Administration has more recently sought to alter its strategy by channelling a portion of its assistance into "growth centers" servicing nearby redevelopment areas. Yet the constraints of the existing authorization still result in most of the funding going to those highly depressed areas that exhibit the least likelihood of achievement.

Overall policy-making setting

Policies . . . what policies?—Thus far I have used the term policy rather loosely, often equating it with program. Most of the specific cases I have used in illustration have been programs, not policies. The reason is simple. Over the past decade policy formulation has been all but buried in a proliferation of narrow, categorical programs. From 1960 through 1968 the number of domestic grant-in-aid programs increased more than eight-fold [7, p. 5]. The current catalogue of federal assistance programs has over 1,000 separate program entries.

Any single issue of national significance, such as poverty or housing or regional development, embraces a long list of program remedies. Each program has its own purpose, its own eligibility criteria, its own administrative machinery. Many report to separate congressional committees for authorizations and appropriations. Is it any wonder, therefore, that a sense of common direction or purpose has failed to evolve for most of these issues, including those concerned with rural affairs?

Beyond its immediate effect on program administration, the absence of clear-cut policy has also considerably confused the communication between government and constituent. In the course of looking for clues that reflect an unstated policy, policy significance is attached to administrative actions that are not indicative of policy at all. In time program administrators become sensitive to this and consequently take to worrying more and more about program appearance and less and less about program substance.

Functional feudalism.— Federal programs have a way of developing their own bureaucratic autonomy and of making control difficult under the best of circumstances. Narrow constituencies extending vertically from grass roots beneficiaries through interest group lobbies, agency bureaucracies, and congressional

committees develop around individual programs. The constituencies enable and promote the autonomy of the programs to which they attach. With the increasing specialization of programs and the phenomenal growth in their number, control has been even further eroded. Critical program decisions are increasingly made by those in the "technostructure" of individual agencies.

> Operational matters flow to the top—as central staffs become engrossed in subduing outlying bureaucracies—and policy-making emerges at the bottom. At the top minor problems squeeze out major ones, and individuals lower down the echelons who have the time for reflection and mischief-making take up issues of fundamental philosophical and political significance [10, p. 42].

This problem is not, of course, limited to the federal level. In some respects the problem of executive control within states is even more acute. The proliferation of federal programs has itself necessitated the creation of additional machinery within the states. The Department of Health, Education, and Welfare alone requires nearly 40 state plans annually for a variety of categorical assistance.

But beyond the customary problems of controlling and directing a large administrative organization, most governors must also contend with sharing their responsibilities with independently elected executives and with complex systems of boards and commissions, most with appointive terms that put them beyond effective gubernatorial control. As of 1967 only 4 of the 50 states elected no other executive official independently (excluding auditors). In short:

> Structural fragmentation amounting to chaos, departmental independence bordering on anarchy, and absence of suitable tools for planning, personnel management, or financial control render an effective administrative performance almost impossible for most governors [2, p. 49].

Conditions within local government are no better, particularly in rural areas, but for different reasons—a large number of very small units, about 60,000 outside metropolitan areas; a myriad of overlapping layers; and, a general lack of professionalism. Only about half of all elected officials are paid for their services and five-sixths serve only part-time [1, p. 17].

Such evidence has led Peter Drucker to conclude:

> Modern government has become ungovernable. There is no government today that can still claim control of its bureaucracy and of its various agencies. Government agencies are all becoming autonomous, ends in themselves, and directed by their own desire for power, their own narrow vision rather than by national policy [3, p. 8].

Centralization of program authority.—Beyond creating an ever-growing number of specialized programs with relatively narrow, functional aims, authority for the implementation of these programs has increasingly been lodged at the national level. This has occurred for several reasons. In part it was a function of the issues coming to prominence—civil rights, poverty, regional development, pollution, etc. —issues of national import. Neither cause nor effect is constrained by state and local boundaries. Furthermore, the magnitude of the tasks could not begin to be matched by local resources. The full, coordinated force of the Federal establishment was needed. And, finally, there was the lurking suspicion that units of government at a lower level were either incapable or unwilling to confront these issues head-on. Indeed, one need not look very far to find evidence that some of these governments had openly contributed to the problems.

While this continuation of the shift toward centralization that began in the 1930's served the useful purpose of focusing national attention and gaining a commitment of national resources "to do something" about these problems, it had other less desirable effects. It made more evident the limitations of centralized decision making. And there are several: First, centralization has necessarily separated the point of problem identification from the point of program design. Program solutions are designed for the problem as seen from afar. Yet the problems often take on different dimensions when viewed close up. Information regarding the problem is seldom generated by the program developer, often contributing to an incongruity between program and problem. There is a tendency, furthermore, to attempt to treat divergent versions of the same problem with a universal solution. Second, given the communication problems imposed by the multiplicity of grantees and grantors geographically separated and the fact that taxpayer money is involved, close management is demanded. This requires an extensive system of application forms, agency reviews, status reports, and all

the various and sundry other items that make up the conventional "bureaucratic red tape." Finally, with the removal of decision making further from the electorate and the general invisibility of those who make the decisions, there has ensued a serious loss of accountability. Those who are most directly accountable to the electorate make comparatively few decisions; those who make most of the decisions are separated, if not entirely divorced, from political accountability.

Implications for the Future

It is a hallmark of our rapidly changing times that we almost always seem to stand at the brink of a critical turning point. Today is no exception. Several things are happening or are about to happen that would seem to have portent for future public policies.

Several key legislative measures will expire within the next few months. These include authorizations for the Economic Development Administration, the Appalachian Regional Commission, the Title V Regional Commissions, and the Office of Economic Opportunity. None of these programs can claim to have been an unqualified success, their genuine accomplishments notwithstanding. It would be surprising, therefore, if at least some of these authorizations were not substantially altered.

In addition to changes in existing programs and policies, several important new ones are waiting in the wings. Two of these—welfare reform and revenue sharing—have the approval and support of the present Administration. Other pending or recently authorized proposals having special significance for rural areas include those relating to new towns, industrial tax incentives, rural credit banks, and rural development highways.

In some respects, therefore, we stand at a policy-making watershed. Decisions made within the next few months will determine the principal configuration of this nation's economic development policy over the next few years. In light of the foregoing assessment, what suggestions can be made for future policy? What are the elements of a leading edge?

Public policy should provide for evolving processes by which debate and trade-offs can occur and whereby constituent interests can reach consensus. Beyond offering the usual static collection of categorical programs, it should set the stage for a dynamic and continuing process of public problem resolution. Furthermore, the process must be of sufficient breadth to cut across the spectrum of major community interests. To establish separate deliberative processes around each of many functional interests, as several existing "grass roots" programs now do, will not lead to the overall community consensus that is so badly needed.

Several innovative efforts to establish such processes are under way. At the federal level two deserve special mention—the federal-wide Planning, Programming, Budgeting System (PPBS) and the Domestic Affairs Council (DAC). The former process is used to resolve detailed policy questions; the latter is reserved for more global issues. While opinions differ as to the degree of success of PPBS, there is general agreement that the system has materially improved the rationality and orderliness of budget making. It can become an even more effective tool, however, if more attention is devoted to the generation and application of well-developed analysis; policy issues of longer-run consequence; overcoming the foot-dragging of hostile bureaus; and developing increased support for and understanding of the system on the part of key policy makers.

The Domestic Affairs Council is too new to the policy-making scene to provide a basis for evaluation. Its first major test will come in the preparation of the Administration's domestic program for 1971 and in designing replacements for key legislation about to expire. The most apparent needs of the Council are for greater access to impartial, highly responsive analytical and informational resources and greater isolation from pedestrian details of comparatively minor policy significance.

Similar innovations are being tried at state and local levels. Several governors have organized PPBS-type units within their offices. Several states are also in the midst of establishing Departments of Community Affairs to assume responsibility for the overall coordination of state development activities.

At the local levels, the brightest hope for evolving a policy process in the nonmetropolitan setting would seem to lie with the multicounty planning and development district concept. Many states are responding to guidelines established by the Office of Management and Budget (Circular No. A-95) and are identifying common systems of substate districts and are designating clearinghouse agencies at both state and district levels to review and comment on applications for a list of some 50 fed-

eral programs. As of July 1970, 50 state clearinghouses and 334 substate clearing houses covering nearly 1,400 counties had been established, 132 of them in nonmetropolitan areas of 22 states. Eventually, this can lead to a nationwide system of about 500 clearinghouses through which state and federal assistance can be channelled.

These district organizations are obviously not without their problems too. If they are to realize their full potential, it will be necessary, among other things, to bring greater order to the grab-bag mixture of federal funding sources that now provide the bulk of their support; to inject greater meaning and relevancy into the planning process by securing it more directly to noncategorical financial assistance; to end the internecine competition of state and federal agencies over who will be credited with leadership; and to bring about a closer integration of the districts with local government, including the assumption of appropriate government functions.

Public policy should enhance the adjustment capabilities of those people whose lives will be disturbed by major economic and social change. As noted above, a preponderence of the policies directed specifically toward rural areas have done little if anything to provide for the adjustment of the individual. A major drawback to forming programs and policies around narrow, functional constituencies is that the larger social interest is often overlooked. Thus, while the benefits befalling the constituency in question are well-represented, the secondary effects—many of which entail costs to other individuals—are not.

Public policy should seek to harness the central economic and social forces of the private sector for the attainment of policy goals. Too many programs either attempt to meet these forces head-on or ignore them altogether. Much of our economic development assistance has sought to prop up or rejuvenate economically depressed areas. This assistance has often taken the form of public works aid—highways in the case of Appalachia, water and sewer systems in the case of EDA. Large portions of the United States are eligible for this aid; nearly 1,000 areas are eligible for EDA assistance alone. Thus, in an effort to provide something for everyone, present policies have had the effect of spreading resources thinly and locating them in places and forms that have proven to be of marginal effectiveness.

Given the level of available federal resources and the strengths of the economic and social adjustments underway, it is unlikely such efforts will ever achieve notable success. Although it will entail some hard political decisions, we must recognize that not every crossroads settlement that chooses to incorporate and call itself a community should be the recipient of public works aid. A far more persuasive case can be made for harnessing the forces of growth associated with small- and medium-scale urbanization and using that momentum for the attainment of regional development aims. The programs of EDA and ARC have moved in this direction, but not far enough.

The same principle merits application in policies guiding the use of natural resources. As the preceeding papers in this session have shown, the demands on these resources are changing rapidly. Nonagricultural uses are growing in prominence. Our concern with the qualitative dimensions of the physical environment, coupled with changing consumption patterns, strongly suggest a substantial increase in the social utility of resources that are kept out of commodity production. Quite apart from the problems of overproduction, it would seem that the positive value of natural environmental amenities and landscape protection will rise relative to the value of increased food and fiber production. Future policy should mirror this shift.

Public policy should seek to internalize a system of accountability. Too many of our existing programs are, in a sense, out of public control. Instead, they are under the benevolent direction of narrow constituencies. Accountability can be improved in a number of ways. The fledgling institutional devices mentioned earlier can help by providing the executive with greater control over functional program elements. The transfer of many of the more detailed management responsibilities to lower levels of government where accountability is more visible and more direct would also help. Revenue sharing could help set the stage for this transfer, although insufficient attention at an early stage to strengthening the capacity of state and local governments to deal with functional interests could result in failure. Greater use of the private sector, as suggested by Peter Drucker, is yet another avenue that merits further exploration [3].

Public policy making has been aptly termed

"the science of muddling through" [6]. Some students of the subject find value in a system that minimizes debate over policy objectives, that moves toward the resolution of issues in incremental steps, and that fosters an intricate system of interest advocacy. Perhaps there is. But there are also obvious drawbacks, some of which I have sought to describe. Perhaps, with the adoption of changes such as those described above, we can evolve a process that muddles less and governs more.

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Soviet Agriculture Revisited

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Soviet Agriculture Revisited

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IN JULY and August 1955 I had the opportunity of visiting the Soviet Union as a member of an agricultural delegation. At that time I visited 30 farms as well as several agricultural research and educational institutions, factories, machine testing stations, and machine tractor stations. My notes of a meeting on the last day of our visit indicates that at least some things have changed very little in 15 years. The meeting was at the Ministry of Agriculture and the Ministry of State Farms; the presumed purpose of the meeting was for the members of the delegation to make recommendations concerning agricultural policy in the Soviet Union. My notes include the following: "At this meeting Soth[1] presented our views that we were not provided the opportunity that had been promised to see what we wanted to see. Instead, we had been taken on a conducted tour with a fixed schedule that could not be changed. He also pointed out that the delegation was handicapped in making recommendations because we were not given basic economic data on Soviet agriculture. We considered this information absolutely basic to the study of any country. Though data on prices, income, production, livestock numbers, and acreages were promised us, the promise was never fulfilled."

While the amount of data on Soviet agriculture has increased substantially since 1955 (the first economic statistical handbook since 1939 was published in 1956), much important information is still not available and could not be obtained by those who attended the XIVth International Conference of Agricultural Economists in Minsk in 1970. I can personally attest to the failure to provide information that was promised, even when the promise was made by a high public official at a public meeting. In response to a question that I asked about the the regional price variations for meat and milk, the Minister of Agriculture, V. V. Matskevich, stated that if I saw him after the session all the information that I desired would be given to me. I did see him after the session, made further inquiries of some of his associates at Minsk, and also made inquiries in Moscow. The latest response was that the price schedules, even though they went into effect May 1, 1970 (and in major part had been in effect for five years), had not yet been published. I still have not received the information.

I make these personal comments to make it clear that my remarks about Soviet agriculture will reflect little that was learned on my recent visit to the Soviet Union. If the hosts had desired to minimize what the foreigners who came to their country could learn about agriculture, they achieved their objective. On the average, including the post-conference tours, participants visited about three carefully selected farms and one or two research institutions. The papers at the conference were singularly uninformative; one can only assume that this was by design since it would have been impossible for intelligent and informed individuals to say so little without making a conscious effort to do so.

I am baffled by the performance of our Soviet colleagues. There seems to be no excuse for such monumental reticence about displaying Soviet agriculture to the outsider. It is true that Soviet agriculture does not compare favorably on many critieria to the agriculture of Canada, Australia, or the United States, or much of Western Europe, but compared to the rest of the world there is much that can be shown with pride. There are many aspects of Soviet agricultural policy that are subject to serious criticism, but few nations now have an agricultural policy of which they can be proud. There is no objective reason why Soviet agricultural economists should not be more open about their agriculture; their failure to be more open leaves one puzzled. It is my opinion that the general circumstances of Soviet agriculture are more favorable than the impression gained by most conference participants; many par-

[1] Lauren Soth, editor of the editorial pages of the *Des Moines Register* and the person who was primarily responsible for the exchange of delegations between the United States and the USSR in 1955.

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ticipants seemed to conclude that so little information was transmitted necessarily because the agricultural situation is quite adverse.

It is a sad commentary that the most informative presentation on Soviet agriculture made at the conference was by Minister Matskevich. He is an able agricultural economist, so one should not have been surprised to hear a useful and informative presentation; but one can be disappointed that the special volume prepared for the conference, *Agriculture of the Soviet Union* [4] and the several speeches were much less informative than the speeches given by L. I. Brezhnev in recent months and years.

In these remarks I shall try to give a review of some developments in Soviet agriculture for the decade from 1958 through 1968. Both 1958 and 1968 were very good years climatically, and more data are available for 1968 than for 1969. Between 1958 and 1968 total agricultural output increased by 35 percent, according to the USDA index of farm output [16]. Total population increased by 15 percent; per capita agricultural output increased by 17 percent [16]. The increase in output per capita was almost identical with that achieved in all industrial countries and greater than in the United States (4 percent).

The increase in output has done little to correct or offset high food prices. A market basket of food priced in April–May 1967 in New York, Moscow, London, Munich, and Paris indicated that if official exchange rates are accepted the basket cost $34.60 in Moscow, $16.66 in London, and $18.27 in New York [11, p. 276]. The highest cost, except for Moscow, was in Munich where it was $22.48. The amount of working time required to purchase the basket was 7.3 hours in New York and 59.2 in Moscow; in Paris 32.1 hours were required [11, p. 276].

Input Changes

The increase in farm output was associated with a number of input changes. Average annual employment in agriculture probably declined from about 43.7 million in 1958 [3, p. 5] to about 39.10 million in 1968 [9, p. 75]; in this series almost all of the decline occurred between 1958 and 1960. The change in employment after 1960 has been remarkably slow by comparison with developments in Western Europe, but not at all different from conditions in the United States when about 40 percent of the labor force was engaged in agriculture (about 1890).

The total area of cultivated land, approximately 220–224 million hectares, changed little if at all over the decade [15, p. 20; 13, p. 55]. The area of fallow land is included in the total for arable land; and it varied significantly over the period, declining from 24 million hectares in 1958 to 6 million in 1963, then increasing to 17 million hectares in 1966.

There were striking increases in some inputs produced by the nonfarm sector. The number of tractors almost doubled, from 924,000 at the beginning of 1958 [10, p. 393] to 1,821,000 by the end of 1968 [13, p. 55]. Fertilizer deliveries (in terms of plant nutrients) increased from 2.46 million tons in 1958 [15, p. 34] to 8.25 million tons in 1968 [13, p. 55], or 235 percent. The increase in the United States over the same period was 141 percent; and fertilizer use in the USSR in 1968 was 70 percent of the U.S. use in the same year. The number of combines increased by less than a fifth, despite the continuing difficulty of completing grain harvesting in a reasonable period of time [15, p. 33; 9, p. 28].

Investment

The decade under review has witnessed an enormous increase in investment in agriculture —from 5.5 billion rubles in 1958 [15, p. 27] to 14.1 billion rubles in 1968 [12, p. 7]. If anything, the purchasing power of the investment ruble in 1968 was greater than in 1958. While the figures are probably not fully comparable, it is worth noting that in 1968 gross capital expenditures on U.S. farms were $6.1 billion. Since 1968, annual investment in Soviet agriculture has increased more than 20 percent. While value added in Soviet agriculture is probably greater than in the United States, the ratio of investment to value added is almost certainly substantially higher in the USSR than in the United States.

For the Ninth Five-Year Plan the total of state and collective farm investment is planned at 124 billion rubles, or an annual rate of 25 billion. While this figure may include some investments of a social and cultural nature, and perhaps governmental, its magnitude should not be underestimated.

The Private Plots—A Touchy Point

Asking a question about private plots does little to increase one's popularity among agriculturalists in the Soviet Union. Minister Matskevich ridiculed the factual basis of a question

raised at the Minsk meeting about the importance and relative productivity of inputs on the private plots. At a meeting with the director of an agricultural economics research institute in Kiev I asked whether the institute did any research on production problems on the private plots. The director did not wait until the translation of the question was completed before he entered upon what can only be described as a tirade against Western economists who exaggerate the importance of the private plots in agricultural output. It was not until the question was put twice more that he listened to the end and his anger subsided. His response was that his institute did little work on the economics of private plots, but other economists in the USSR had published on the topic.

The private plots are very important in the Soviet Union, despite any disclaimers that might be made to the effect that plots are really not separate from socialized agriculture. According to USDA calculations, 30 percent of the gross agricultural output is produced on the more than 30 million private plots [13, p. 56]. According to official Soviet data, almost 40 percent of meat and milk and 60 percent of eggs, as well as over half of all fruits and vegetables, are grown on private plots [13, p. 57]. The private plots have 3 percent of the cultivated area [13, p. 57]; and, perhaps somewhat surprisingly, the gross output per worker is approximately the same on the private plots as in the socialized sector.

The existence of the private plots has a significant negative effect upon the socialized sector, especially upon the collective farms. Even though payments per man-day of work on collective farms more than doubled between 1958 and 1968, my colleague, Arcadius Kahan, estimates that it is still true that an individual can earn more from a day's work on his private plot than he can by working on the collective farm.

One of the important reasons for the increased payments to collective farms was to increase labor participation in the socialized sector by the members of the collective farms. The evidence indicates that nothing has happened—neither the number of days worked per worker nor the seasonal distribution of work changed during the 1960's. One of the problems of labor use on collective farms has been the conflict during critical periods between work on the farms and on the private plots. It is still necessary for several million people, often college students, to leave the cities to work on farms during the harvest season; and I have recently seen a reference to the same phenomenon during the spring planting season.

Changes in Labor Requirements

As noted above, there were major increases in current inputs purchased from the nonfarm sector and a very high level of investment achieved in the 1958–68 period. Farm output did increase significantly during the period, and to some very significant extent the output increase can be attributed to the increased inputs. However, an important reason for the increased inputs and investment is to increase output per worker. Data presented in *Agriculture of the Soviet Union* [4] on average labor requirements in the USSR permit a comparison of changes in labor requirement for the period 1960–68 with a similar period for the United States.[2] These data are given in Table 1, as are the estimates for the United States. The primary emphasis is not upon the absolute levels of labor requirements in the two economies but upon changes over the eight-year period.

The largest reduction in labor requirements in the USSR was for grain produced on collective farms—62 percent; a major change also occurred in pig production on both collective and state farms. There does appear to be a pattern to the instances in which reductions in labor requirements in the USSR were either greater or less than in the United States. When the labor requirements per unit of output for the beginning year were approximately ten or more times those in the United States, the reduction in labor requirements in the USSR tended to be greater than in the United States. When the original difference in labor requirements was less than seven or eight, the reduction in labor requirements in the USSR tended to be less than in the United States.

The increasing and high level of investment did not seem to pay off in terms of significantly reducing the large gap between labor requirements in the two agricultures. The reduction in labor requirements per unit of output in the USSR was probably about 30 percent. This is a significant reduction in a period of eight years; however, the investment costs of achieving such a reduction appear to be very high in comparison

[2] The time periods are not identical since for the United States the comparisons are for five-year periods that have midpoints eight years apart (1957 to 1965).

Table 1. Labor requirements, USSR and United States (man-hours per center)[a]

Product	USSR Collective farms 1960	1968	Index[b]	USSR State farms 1960	1968	Index[b]	United States 1955–1959	1963–1967	Index[b]
Grain[c]	6.0	2.3	38	1.8	1.3	72	0.6	0.4	67
Cotton, raw[d]	47.6	37.1	78	42.7	30.1	71	11.5	5.6	48
Sugarbeets	2.7	1.6	59	2.8	2.1	75	0.32	0.22	69
Potatoes	5.6	3.8	68	4.9	3.2	65	0.66	0.44	67
Cattle	102.9	65.1	63	57.4	46.2	80	7.0	4.8	69
Pigs	116.2	54.6	47	49.7	27.3	55	5.3	3.3	62
Milk	18.3	13.0	71	12.5	9.4	75	3.7	2.2	59

[a] Original data for U.S.S.R. in man-days: assumed 7 hours per day.
[b] Later year as percent of earlier year.
[c] Excluding corn for U.S.S.R. only; wheat for United States.
[d] One bale of lint cotton (500 pounds) assumed equal to 6.4 centners of raw or unginned cotton.
Sources: U.S.S.R. [5, p. 123]; United States [14, p. 461].

to the costs of an equal reduction in the United States.

Agricultural Price Policy

While this paper is primarily concerned with a discussion of Soviet agriculture from 1958 through 1968, it is not possible to adequately understand the changes in price policy without going back to the late Stalin era. In 1952 (and the years before) the procurement prices for almost all food products were so low as to be confiscatory. The price of grain for compulsory deliveries in 1952 was 9.7 rubles per ton, and no grain was delivered at the above-quota price of 12.5 rubles in that year [7, p. 79].[3] Thus the average price for a bushel of wheat was the equivalent of 30 cents. In 1952 the average procurement prices for cattle and hogs were, respectively, 50 rubles and 70 rubles per ton [7, p. 79]. These would convert, at the official rate of exchange, into prices of approximately $2.50 and $3.50 per hundredweight.

The price of cotton, however, was very favorable at 315 rubles per ton of raw cotton;[4] including the associated value of cottonseed, this works out to about 45 cents per pound of lint.

Significant increases in procurement prices for grain, potatoes, vegetables, and livestock products were announced in 1953; further increases occurred in 1955 (grain) and in 1956. In 1958 the multiple price system was abolished in favor of a single price for all procurements. Data in Table 2 indicate 1958 grain prices were 7 times as high as in 1952; 8 times for potatoes; 5.5 times for meat; 4 times for milk; 3 times for eggs. The 1958 cotton price was approximately the same as in 1952, while the prices for wool, sugar beets, and flax were a little more than double.

Some farm prices were increased in 1962 and there were major increases in livestock and butter prices. In 1965 livestock prices were once again increased substantially (29 percent); the increase in the price of milk was approximately 16 percent (see Table 2).

In 1965 the policy of a single purchase price was abandoned in favor of a multiple price system for grains; the premium for deliveries in excess of the purchase plan was set at 50 percent. A similar change in policy was introduced for livestock and milk in 1970, subject to a condition to be noted later.

The other 1965 innovation in price policy was the introduction of large zonal differences in prices. The basis for the zonal prices is stated by M. M. Sokolov: "The average cost of production in every specialized zone determines the purchase price for farm produce. In calculating the average cost of production, the last three to five years are taken. Staple crops and the key branches of agriculture can have the greatest divergences from value within a given zone, e.g., grain in the Kuban and the virgin lands, cotton in Central Asia, and flax in the areas of Non-Chernozem Zone. There the purchase price stimulates production of those farm products which have the lowest cost in the given area." [4, p. 194].

The differences in the zonal prices are very great (see Table 3). For example, the procurement price for wheat in the Ukraine (excluding

[3] All references to rubles are to the current ruble which has an official exchange rate, according to the government of the Soviet Union, of $1.11. This is the rate at which conversions are made into dollars. Unless indicated to the contrary, all weights and measures are metric.

[4] Derived from Tables 2 and 3.

Table 2. Indexes of average procurement prices paid to collective farms and individuals, USSR, selected years, 1952–1967

	1952	1953	1955	1956	1958	1960	1962	1964	1966	1967
All	100	154	209	251	296	299	334	355	420	430
Crops	100	132	169	207	203	202	219	235	270	276
Grains	100	236	553	634	695	717	834	834	1133	1188
Cotton	100	105	114	115	106	108	108	124	139	142
Sugarbeets	100	144	130	229	219	215	232	276	276	276
Sunflowers	100	528	987	928	774	766	859	851	1122	1122
Potatoes	100	316	368	814	789	884	1041	1468	1294	1389
Livestock and products	100	214	319	371	546	562	639	677	824	835
Meat animals	100	385	585	665	1175	1246	1528	1622	2092	2115
Milk	100	202	303	334	404	404	436	457	529	537
Eggs	100	126	152	169	297	309	347	353	350	353
Wool	100	107	158	246	352	345	345	370	377	387

Sources: [6, pp. 412–413, and 1, p. 68]; separate series linked at 1958.

the Poleyse region) and Moldavia is 76 rubles per ton; in Belorussia, the Poleyse region of the Ukraine, the Baltic republics, and the large parts of the RSFSR, the price is 130 rubles. For cattle the procurement price is about 1100 rubles per ton in the Ukraine and 1600 rubles in Belorussia, which borders on the Ukraine. As indicated by the quotation from Sokolov, the variations in average costs of production among zones are at least as large as the zonal price differences.

The second part of the Sokolov quotation contains a rather explicit criticism of the zonal price differentiation policy. As the writer notes, within a given zone the purchase price "stimulates the production of those farm products which have the lowest cost in the given area." If this is true within a zone, why would it not be true among zones if prices were differentiated by only the costs of marketing and transportation?

There are probably two main reasons why such large zonal price differences are required. The first is the absence of any charge for land; the collective farms in the Kuban have been given an enormous source of productive power in their rich land while the collective farms in Central Nonblack Soil area received very little. If the Soviet government charged rent reasonably related to the value and productivity of land, at least part of the regional income differences that would exist with uniform prices (except for transportation costs to the deficit consumer areas) would be eliminated. But not all.

The second factor in the substantial regional income differences that have existed in the past (and still persist though to a lesser degree) has been the absence of labor mobility among collective farms. There are very substantial differences in the labor/land ratio, with the highest labor/land ratios existing in the central and northwestern regions. These comparisons do not include the Central Asia areas with their labor-intensive crops. Failure of labor mobility to eliminate regional income differentials within agriculture is not unique to the USSR, of course. But the combined lack of land rent and limited labor mobility created exceedingly serious discrepancies in farm incomes, and the response was widely differentiated purchase prices by zones. In terms of efficiency in production, the solution is a costly one, but failing the imposition of land rent and improving intra-agricultural labor mobility it was probably the most reasonable solution.

The purchase prices for livestock products that were announced in July 1970 have a num-

Table 3. Minimum and maximum zonal purchase prices, 1965, and average procurement prices, 1967, USSR (rubles per ton)

	Number of zones	1965 zonal prices: Minimum	1965 zonal prices: Maximum	1967 average procurement price
Wheat	15	67	130	103[a]
Barley	7	48	90	
Sugarbeets	5	27	40	27
Sunflower	6	165	225	214
Milk	15	130	230	156
Cattle	17	956	1827	1201
Hogs	15	1000	1997	1451
Sheep	14	483	1224	849
Cotton (raw)				452

Source: [1, p. 98].
[a] All grain; in 1967 RSFSR average price of wheat was 99 rubles per ton [1, p. 148].

ber of interesting features [2, p. 2]. First, there are no seasonal price differentials. Second, very substantial penalities are imposed for cattle, sheep, and hogs that are of less than average fatness—reductions of 20 to 25 percent. Third, indicating the strong emphasis still given to increasing the supply of fat, premiums of 20 percent are paid for cattle and sheep of better than average fatness. Fourth, a premium of 50 percent is to be paid for all livestock products sold in excess of the annual plans by collective and state farms.

It is of more than passing interest that the receipt of the premium for sales in excess of the annual plan requires "that there has been an increase in the number of animals the farm had on hand at the beginning of the year" [2, p. 3]. In the Eighth Five-Year Plan there was no reference to goals for livestock numbers. This was presumably an acceptance of the tenet that the individual farms should have more freedom in their decision making so long as the annual purchase plans were met. But apparently old ideas die hard. Now pressure is to be put upon farms to continuously increase livestock numbers, since this is a requirement for receiving the premium.

The purchase price for cattle in Belorussia is 1600 rubles per ton (72.7 rubles per hundredweight). In addition to this base price, there is a marginal pricing scheme for young cattle that is probably without peer in the world. If a calf weighs between 350 and 400 kilograms, the supplement to the base price is 35 percent; if the weight is over 400 kilograms, the premium is 50 percent. The marginal gain from increasing weight from 325 to 375 kilograms would be 290 rubles (263.6 rubles per hundredweight) and from 375 to 425 kilograms, 210 rubles (190.9 rubles per hundredweight). It was no wonder that one of our Irish colleagues at the meeting said that he was going back home to argue that the Irish farmers should join the USSR rather than the EEC!

While one of the reasons for the zonal price differences was to reduce regional income differentials, the premium for above-plan deliveries has two important effects upon income. First, given that planned sales are now fixed for a five-year period and are presumably not adjusted to year-to-year changes in output, the incomes of collective farms will fluctuate more from year to year than would be the case if a single price were paid. In a year when yields are low, no sales will be made at the premium price; in a year (such as 1968) when yields of the grains are high, a substantial fraction of sales to the procurement agencies will be at the premium price.

Second, either errors in establishing the purchase plans for given farms or differences in conditions favoring output increases within a plan period can result in significant income differentials among farms. A farm with a favorable delivery plan will be able to sell more at the premium price, while a farm that has a greater than average rate of output growth will gain significantly compared to a farm with a stable output. Differences in income would occur under a single price, but differences are exaggerated by the multiple price system.

The high absolute prices paid to farms for livestock and milk are apparently higher than Soviet planners believe Soviet consumers would accept. Consumer prices for meat and milk in the state stores have remained unchanged since 1962 when, or so it was rumored, there was considerable public resentment of higher meat and milk prices. Consequently all of the costs of price increases for livestock and milk since 1962 have been paid from the budget. I do not know how large the subsidy is, though rough calculations that Alec Nove and I made in Minsk indicated that the total for 1970 might be as much as 10 billion rubles. Efforts at Minsk to determine the amount of the meat and milk subsidy were unavailing, though it is perhaps worthy of note that no one contradicted the 10 billion ruble estimate.

Earlier it was shown that the average prices received by collective farms for sales to governmental agencies had increased substantially between 1952 and 1968, especially so in livestock and grains. The last column in Table 3 gives the average procurement prices for 1967. Since then cotton and milk prices have been increased; the average purchase price for milk should now be at least 190 rubles, and this includes no premium for above-plan deliveries. Any comparison with producer prices in other countries is complicated of course by lack of information concerning the true exchange value of the ruble. At the official exchange rate, the average procurement prices are high in comparison with the EEC, the differences for cattle and hog prices being of the order of 100–125 percent

Boev [1, p. 175] has made some comparisons between the number of tons of wheat required to purchase certain items of farm machinery in the USSR, USA, Canada, and West

Germany. In 1966 a tractor that cost 20 tons of wheat in the USSR cost 75 tons in the United States, 68 tons in Canada, and 40 tons in West Germany. A combine that cost 40 tons of wheat in the USSR cost 95, 126, and 117 tons, respectively, in the United States, Canada, and West Germany. If these comparisons are typical of output price/input price relationships in the USSR, the official rate of exchange may not be invalid for making international comparisons of output prices. However, one can discount the official rate of exchange by half and still find that most of the USSR prices are at least as high as those received by farmers in the United States. In any case, I think it would be most inappropriate to use the black market exchange rates, which range from 3 to as many as 6 rubles per dollar, for purposes of comparison.

Returns to Labor

Efforts have been made in recent years to assure that the higher prices are reflected in the incentives available to the collective farm members. A most important change has been the institution of guaranteed monthly wages. Formerly the majority of the farms paid only or largely at the end of the year, and since the funds available for distribution tended to be a residual after all other expenses and commitments were met, the payment varied widely from year to year. Another change has been the strong pressure from the government to raise the guaranteed payment to the level of comparable workers in the state farms. From the information given to us, the guaranteed pay for collective farm workers appears to be 3.6 rubles per day in the Ukraine and Belorussia. V. A. Tikhonov [11, p. 167] states that the annual income of collective farmers from the collective farm increased by 120 percent between 1960 and 1967. Assuming that there had been some small increase in pay to collective farm members between 1967 and 1969 and that the number of days worked per year has remained unchanged, this implies that average pay per day in 1960 was about 1.5 rubles per day.

Some Concluding Comments

The USSR has a high-cost agriculture. It is high cost in several senses. Consumer costs for a relatively limited selection of foods are high relative to incomes; even so, a large subsidy is required for meat and milk to make up the difference between prices paid to farms and prices paid by consumers. The level of investment in agriculture is high and is planned to increase even further during the next plan period. There is little reason to believe that much success will be made during the present decade in making Soviet agriculture both more efficient and more responsive to consumer demand.

There are many reasons for the high-cost status of Soviet agriculture. One is the policy of autarky in farm products combined with significant limitations in the quality of Soviet land resources. But other factors are clearly significant, including the very large size of farms in the socialized sector, the unwillingness of planning and control officials to permit a wider range of decision making at the farm level, the poor performance of research institutions in the fields of mechanization and animal breeding, and the generally inadequate functioning of farm machinery production and supply. Farm machinery is still of low quality, requiring high maintenance costs and frequent interruption of service for repair.

While I believe that family-operated farms are more efficient than collective and state farms, I am coming to the opinion that the shortcomings of the institutions of collective and state farms are not the primary causes of the present unsatisfactory state of Soviet agriculture. It is the framework of regulations and controls within which the farms must function, the inadequate functioning of the rest of the economy in supplying farms with appropriate inputs, and the failure of the marketing and distribution system to provide satisfactory and assured market outlets for perishable and semiperishable farm products that must bear much of the responsibility.

Despite frequent references to the role of incentives in economic activity, including agriculture, the real operating principle that seems to guide agricultural planners and officials is that the farms cannot be trusted to make the appropriate decisions. While there is a great deal of objective evidence to support this conclusion, the basic idea was well put in a speech at Minsk by A. M. Rumyantsev:

> Every collective farm cannot take into account society's real needs in agricultural products. This can be done only by socialist society as a whole. The latter makes the necessary information available to all collective farms in a centralized way, by drawing up its firm plan of purchasing farm products, by placing orders with these

farms and thus ensuring the stability of their production.

The firm plans may serve the interests of the bureaucrats, who apparently try to avoid uncertainty, or of the marketing and procurement agencies; but it is impossible to show how firm plans for a required minimum sale can be superior to the opportunity to sell any desired amount at firm prices. With the present level of prices paid to farms, the farms could produce more if the rest of the economy served them better. Much of Soviet agriculture has a relatively harsh natural environment and relatively little can be done about this. But its economic and political environment could be substantially improved. And only time will tell whether any significant changes are forthcoming. Recent decisions, including the Ninth Five-Year Plan and the 1970 price announcements, indicate that there is little prospect for significant change before 1976.

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Discussion: DALE E. HATHAWAY, *Michigan State University*

Evaluating the professional progress in Soviet agricultural economics is difficult for one who does not read or speak the language; therefore my judgments are necessarily based upon the professional performance of the participants in the recent I.A.A.E. meeting and upon a longer visit in the Soviet Union three years ago, when I was accompanied by colleagues who were competent in the language.

I would make several observations on the recent meetings. The Russian-English translation was inadequate, and some of the Russian papers and comments may have suffered as a result. Second, most of the Russians attending the conference were older men, relatively high in the various bureaucracies; the younger men, in sharp contrast to the Western delegations, were absent. One Russian privately confirmed my impression of this latter point.

There was a noticeable lack of economic analysis in the content of the meetings and an excess of ideology in most of the Russian papers and comments. Moreover, unlike their U. S. counterparts who are anxious to discuss problems and policies, the Russians never admit they have any problems in agriculture and never really discussed policy issues at the meetings. However, in a country where open dissent often results in demotion or detention, the lack of counterparts to our Galbraiths and Cochranes is hardly surprising.

Unfortunately, this internal attitude is ex-

tended to international professional meetings. The extraordinary reaction of the Russians to the somewhat critical comments made by John Dillon of Australia and Dennis Bergmen of France was frightening as well as amusing. Westerners are accustomed to hearing critical policy evaluations made publicly and debated openly; it was clear the Russians were not.

The discussion groups varied in terms of depth and analytical content. In my own, a large group of Russians participated well after some initial confusion over ground rules and despite relatively poor sequential translation. The discussion on credit and capital reportedly went well. In many discussion groups, however, the Russians were reported to have presented prepared statements rather than to have participated in discussions.

My impression from this visit and the earlier one was that economic analysis has very little to do with the allocation of resources within or among farms. At the farm level it appears that the economist is primarily an accountant. Someone may have an excellent rationale for how resources are allocated, but it is never explained to visitors. Moreover, in discussing the training taken by some of the farm-level economists, I never found one who had had a course in production economics, which may explain why the agronomists and the party leaders make the local decisions on resource allocation.

I had been told of a new breed of Russian mathematical agricultural economist who is sophisticated in applications of linear programming and other modern techniques. These persons were not present in significant numbers at the meetings, nor was there any evidence on the farms that their work is being applied to improving resource use in Russian agriculture. Herein lies the rub in judging the quality of work done by Soviet agricultural economists. Their analysis and recommendations are not generally known to outsiders. Decisions in the Soviet economy clearly are political to a large extent, and it is impossible to tell what part, if any, economic analysis plays. Indeed, one wonders whether the individual economist knows where his own analysis blends into party dogma. We can only imagine the exciting discussions one might have with Soviet colleagues in a socialist system if the system were open to investigation, analysis, and discussion.

Discussion: ROY D. LAIRD, *University of Kansas*

Since my first visit to the rural USSR in 1960, major changes have occurred in Soviet agriculture. Farm size has nearly doubled, while rural population has declined slightly. As illustrated in Table 1, production has increased significantly, both in absolute terms and in terms of per capita availabilities.

The advances of the past ten years reflect significant increases in agricultural investment. A guaranteed minimum wage is being adopted by the kolkhozy; farmer incomes have probably doubled; prices paid by the state have greatly advanced. As illustrated in Table 2, more machinery, and much greater amounts of mineral fertilizer are among the important changes in inputs.

Increased investment in agriculture was accompanied by a shift from Khrushchev's heavy reliance for the key crop grain upon the once virgin, but arid, new lands (at the peak some 36,000,000 hectares) to a clear recognition that virtually all future advances must come from greater yields per hectare on the established farming areas. "Intensification" has become the watchword. Grain yields per hectare increased some 30 percent—from 10.2 to 13.2 centners per hectare for all grains and pulses. Further investments in fertilizer, irrigation, etc., will be realized in the 1970's.

Western students of Soviet agriculture have long pointed to the need for much higher investments. However, such specialists also have argued that much of the production problem in Soviet agriculture (especially low labor productivity and low yields) is linked with political (i.e., organizational and administrative) shortcomings in the system. In our opinion such costs may be as much as half the problem, and

Table 1. Production increases, 1966–69 over 1956–60, in percentage[a]

	Grain	Sugar-beets	Potatoes	Meat	Milk	Eggs
Total	31	80	7	44	39	55
Per capita	14	54	−8	25	20	38

[a] Derived from official Soviet statistics, averages for each period; 1970 not available.

Table 2. Key input changes, 1957 to 1967[a]

	1957	1967
Sown area (millions of hectares)	193.7	206.9[b]
Number of farms (kolkhozy plus sovkhozy)	84,100	49,600
Sown hectares per farm	2,300	4,160
Workers (all farms and subsidiary enterprises; millions, 1960 vs. 1968)	29.0	27.5
Sown hectares per worker	7.0	7.5
Mineral fertilizer (millions of tons available)	10.4	33.7
Mineral fertilizer (kgs. per sown hectare)	50	160
Number of tractors (15 hp. units, thousands)	1,635	3,485
Sown hectares per tractor (15 hp. units)	—119	59
Sown area in grains and pulses (millions of hectares)	124.6	122.2
Number of grain combines (thousands)	482	553
Sown grain and pulse hectares per grain combine	254	220

[a] The mid-year of the 5-year planning period, derived from official statistics.
[b] At the peak of the new lands campaign in 1963, the sown area reached 218.5 million hectares.

few or no advances have been achieved here since 1960.[1] The huge farms have become even larger and thus more difficult to manage. For example, although the move to a guaranteed minimum wage has been paralleled by the elimination of the cumbersome old *trudoden* ("labor-day" unit, really a piece-work measure), our questions to farm chairman revealed that the premia scheme (i.e., bonuses for extra work and achievement) still requires each farm to keep track of "thousands" of work norms. Each peasant's performance must be duly recorded daily.

Leonid Brezhnev has not meddled with specific farms and regions the way that Khrushchev did as he repeated the "cult of personality" sin. Nevertheless, Brezhnev's recent speeches have stressed that greater discipline (Party imposed from above) is to be a major key to future advances. The Stalin kolkhozy and sovkhozy were primarily designed as institutions of control over the peasants and their product. (Of course, these institutions also brought the "advantages" of communism to the countryside.) These Stalinist farms remain intact, and neither the new 1970 farm constitution (little changed from the 1935 "model" charter) nor the leadership's pronouncements indicate that any significant changes in the system are in the offing. The farms will remain huge rural bureaucracies; and Moscow will continue to issue its plans and directives, including compulsory deliveries by the farms of the bulk of their produce at set state prices.

My analyses indicate that further production advances from still greater investments alone probably have reached a point of diminishing returns.[2] Moreover, bad crop years will return (such as the one in 1963, which precipitated Khrushchev's ouster). Probably more than one bad year will occur prior to 1980, years that should underline serious faults in the present system. At that time major organizational and administrative changes may be inaugurated, changes that must eventually come.

[1] See especially [1]

[2] This conclusion is documented in our forthcoming "Problems of Communism" article.

Reference

[1] LAIRD, ROY D., AND BETTY A. LAIRD, *Soviet Communism and Agrarian Revolution*, Harmondswork, England, a Pelican Original, 1970.

Discussion: JAMES S. PLAXICO, *Oklahoma State University*[*]

Soviet farms are very large and involve diverse economic activities, including provision of infrastructure facilities and services such as education, health, cultural, recreational, transportation, communications, and housing. In terms of the U. S. experience, Soviet farms invite comparison with the public *and* private economic activities in a rural MCD such as a township or county.

On both State and collective farms, the State owns the land and there are many small farms (individual plots) within a farm. Personnel on State farms are State employees, while collective farm managers and workers (members) are elected by members. Collective farm workers now receive a fixed wage plus a share of profits.

[*] Oklahoma Agricultural Experiment Station Journal Article 2169, entitled "Impressions of Soviet Farms and Markets."

Comments such as "Russia has no unemployment nor poverty" were heard frequently. It appears that agriculture in the planned economies, as in enterprise economies, serves as a manpower pool. There appears to be a great deal of underemployment in the farm sector. This was particularly evident on a collective farm near Tashkent. On that farm cultural and educational aspects of the farm such as the opera house, the children's music group, and kindergarten and boarding school received unusual emphasis.

In the Uzbek Republic we observed no farming operations in process, only individually-owned livestock and, with the exception of cotton pickers, no farm machinery at close range. The same was true on a large collective livestock farm in Byelorussia. Perhaps livestock, machinery, and labor represent current problems in Soviet agriculture, but tour groups in older agricultural regions saw beef, swine, and dairy operations.

The Hunger Steppe project in South Central Asia may represent some of the best in terms of Soviet planned agricultural development with eventual large-scale State trading in international markets. The project consists of converting one million hectares of uninhabited, salty desert land into irrigated State cotton farms. There are problems, but the evident progress is most impressive. The processing system involving large seed cotton collection-storage stations and year-round ginning could be highly efficient.

Produce of collective and State farms is mostly sold to the State. State receiving, storage, and distribution facilities were not observed. Commodities are apparently traded in these markets at established prices. In farmers' markets, where produce of individual plots is sold, apparently production above the quota from State and collective farms is sold when prices so indicate.

Farmers' markets are apparently most important for fresh meats, fruits, and vegetables. However, a vast array of commodities were being traded in the farmers' markets in Minsk and Tashkent. Officials implied that farmers' markets are an unimportant part of the economy. However, there were indications that governmental agencies systematically collect prices in these markets. The manner in which this information is used in establishing State prices is not clear.

Only limited observations of the input markets were made. However, a State farm manager in the Uzbek Republic gave a price about one-tenth the U. S. price for a two-row cotton picker. The organization of agricultural education and research were not determined, but each farm has a professional staff including engineers, agronomists, economists, and accountants. The role of profits as a performance measure was evident, but conceptual differences precluded an understanding of the Soviet system of accounting.

A first visit to a planned economy proved to be instructive. Progress observed and the impact of priorities on the pattern of progress were impressive. It is clear that there is a role for economists in planned economies and that we should develop a better understanding of Russian agriculture and the agricultural economics profession in planned economies.

Discussion: W. NEILL SCHALLER, *Farm Foundation*

The fourteenth Conference of the International Association of Agricultural Economists, held in Minsk, USSR, was attended by some 700 participants from 59 countries. There were 211 from Western Europe; 203 from Eastern Europe; 120 from Latin America, Africa, and Asia; and 103 from the USSR Soviet interest in the conference was indicated by the fact that there were ten conference applicants for every USSR participant.

Most of the applicants had no difficulty obtaining Russian visas. Through the efforts of IAAE officials a few Israeli economists obtained visas, but visas were denied applicants from South Africa.

As one might expect, there were unique problems of holding the conference in the USSR, due mainly to inflexibilities in the Soviet "system" of handling changes in arrangements. At times it seemed that Intourist had far more responsibility than experience in conference management. However, the Organizing Committee, a separate group, worked hard at minimizing problems and solving those that arose. What each of us expected in the way of arrangements undoubtedly flavored the impressions we brought home.

The Russian papers were criticized in formal presentations and in informal discussions for failing to do more than defend the Soviet

agricultural system. The resulting tension persisted despite some improvement during the conference in the willingness of Soviet participants to at least acknowledge their agricultural problems and to talk realistically about economics. The informal climate afforded by discussion groups undoubtedly helped.

There were suggestions of conflict between younger and older Soviet economists. The younger participants, though relatively few in number, seemed interested in being economists more than "theologians." It is possible that the conference will have a long-run impact on the thinking of younger Soviet economists and, therefore, on the future role of economics in Soviet agriculture. This conflict, along with the criticism of Soviet papers, also might have influenced the thinking of participants from the developing countries and possibly Eastern Europe.

At its business meetings in Minsk the IAAE Council—the governing body of the 1,900-member Association—discussed a range of issues, including the desirability of holding regional conferences on specific topics between major conferences, which are held every three years.

Kenya and Brazil invited the Association to hold its 1973 conference in those countries. The officers will select the site at a meeting in January, 1971.

The Council elected S. R. Sen of India the new president of IAAE, replacing Dr. Nils Westermarck of Finland. Dr. Sen is currently with the World Bank in Washington, D. C. Kenneth Hunt of the United Kingdom was elected vice-president; and Joseph Ackerman, with the Ford Foundation in India, was re-elected secretary-treasurer.

The purpose of IAAE is to foster the development of agricultural economics and its application to the goal of improving agriculture and rural life. The Association provides an unequalled forum for dealing with economic problems within and between countries in a world that grows smaller every day. I left Minsk with a new awareness that the USA is not the only home for competent agricultural economists and innovative research.

ECONOMIC DEVELOPMENT OF AGRICULTURE
(Joint Session, AAEA and AEA)

CHAIRMAN: W. W. McPHERSON, Florida University

Simulation of the Market for Foodgrains in India

HOWARD BARNUM

THE CENTRAL inquiry of this paper is concerned with the effect of the introduction of stochastic terms on the reliability of deterministic conclusions obtained from simulation. Using an estimated market model,[1] two policy questions—the impact of imported surpluses and the management of government stocks of foodgrains—are examined in the context of stochastic simulation. For each policy question three groups of simulation experiments are conducted and the results compared: (1) The model is used in its deterministic form; (2) random disturbance terms are added to the stochastic equations; (3) random disturbance terms are added to particular coefficients.

In the analysis that follows only one aspect of each policy question is examined, and the results are not meant to supply all of the information that would be needed for a policy evaluation. However, the examples shed new light on the two questions and indicate the usefulness of stochastic simulation in the construction of confidence intervals around deterministic conclusions.

The Model

The model consists of nine equations, five of which are stochastic and explain prices, income, commercial imports, area sown, and yield per hectare. Two-stage least squares were used to estimate the coefficients. The estimated equations, over the 17 annual observations for the period 1948–64, are given below. $\bar{R}^2$ is the adjusted coefficient of determination; d is the Durbin-Watson statistic, and SE is the standard error of the estimate. Standard errors of the estimated coefficients are given in parentheses. The five stochastic equations are:

Price equation:

$$(1)\quad \underset{}{PIFG_t} = \underset{(62.6)}{9.69^*} - \underset{(.00062)}{.00153\,DFG_t} + \underset{(2.93)}{2.27\,YN_t^*} + \underset{(.000101)}{.000207\,N_t} + \underset{(.212)}{.421\,PIDS_t}$$

$\bar{R}^2$ = not applicable

$d = 1.80 \qquad SE = 5.59$

where

- $PIFG_t$ is the deflated price index for foodgrains;
- DFG_t is the total quantity (gross) of foodgrains consumed;
- YN_t is the real net national product per capita;
- N_t is population; and
- $PIDS_t$ is a deflated price index of demand substitutes.

Income-generating equation:

$$(2)\quad Y_t = \underset{(484850)}{2469800} + \underset{(11.14)}{70.76\,QFG_{t-1}} + \underset{(.317)}{3.256E_t}$$

$\bar{R}^2 = .98 \qquad d\dagger = 1.46 \qquad SE = 233478$

where

- Y_t is net national product;
- QFG_{t-1} is the gross production of foodgrains in year t-1; and
- E_t is the total central and provincial government expenditure.

Imports equation:

$$(3)\quad MFG_t = \underset{(1337)}{7335} - \underset{(.0224)}{.1287\,X_t} + \underset{(.02626)}{.04630\,BY_t}$$

$\bar{R}^2 = .73 \qquad d = 1.76 \qquad SE = 738$

[1] The model, data specification, and the estimation procedure are discussed in a paper available from the author [1].

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where

MFG_t is the volume of non-PL 480 imports;
X_t is the availability of foodgrains before commercial imports; and
BY_t is a measure of foodgrain import capacity.

Area equation:

$$AFG_t = \underset{(26940)}{27712^*} + \underset{(.2048)}{.4537}\, AFG_{t-1} + \underset{(120.5)}{234.4}\, PIFG_{t-1} + \underset{(387.0)}{900.3}\, T + \underset{(66.5)}{111.7}\, WS^* \tag{4}$$

$$\bar{R}^2 = .92 \qquad d = 1.94 \qquad SE = 2902$$

where

AFG_t is the area sown to foodgrains;
T is time; and
WS_t is a weather index for the pre-sowing period.

Yield equation:

$$ZFG_t = \underset{(.0561)}{.4875} + \underset{(.0000428)}{.0002604}\, F_t + \underset{(.000709)}{.001184}\, W_t^* \tag{5}$$

$$\bar{R}^2 = .74 \quad d\dagger = 1.59 \quad SE = .03079$$

where

W_t is a growing season weather index; and
F_t is an index of fertilizer use.

The model is completed with the addition of four identities defining (1) the quantity of foodgrains given area and yield, (2) demand, (3) the availability of foodgrains before imports, and (4) per capita national product. The identities are

$$QFG_t = AFG_t \cdot AFG_t \tag{6}$$

$$DFG_t = MFG_t + QFG_{t-1} - \Delta GFG_t + MPFG_t \tag{7}$$

$$X_t = QFG_{t-1} - \Delta GFG_t + MPFG_t \tag{8}$$

$$YN_t = Y_t/N_t \tag{9}$$

where

ΔGFG_t is the volume of additions to government stocks; and
$MPFG_t$ is the volume of foodgrain imports under PL 480.

In total, there are 9 endogenous variables and 15 predetermined variables, 3 of the predetermined variables being lagged endogenous.

Four features of the model can be noted briefly. First, lagged area, derived from a Nerlovian adjustment model, is used in the area equation. This was thought to be important for India where there are significant traditional and institutional restrictions on resource allocation. Second, area and yield equations are separated, as was found to be useful by Bernard Oury [3] in his estimation of foodgrain supply in France. The usefulness of this approach for the present model is derived from the divergence between area and yield price responses expected for India. Third, foodgrains, which constitute approximately 27 percent of the total Indian national product, are included as a factor in the income-generating equation. Thus income change is generated not only directly from additional output but indirectly as well through multiplier effects. Finally, the import equation is derived with reference to a planner's welfare function constrained by the availability of foreign exchange. The variable BY is therefore a composite of the value of exported goods plus net capital flows deflated by the price of foodgrains imports relative to other imports.

Application No. 1—the Impact of Public Law 480

Several economists have suggested that the importation of surplus foodgrains under Public Law 480 may have had deleterious effects on the agricultural sector of the Indian economy. The question involves the response of farmers to decreases in foodgrain prices attributable to the imported surpluses. In order to make a thorough evaluation one should know the institutional and structural nature of resource reallocation accompanying diminished agricultural output. But via simulation a tentative answer can be offered to the central questions, what has been the amount of farm output response and what has been the effect on the availability of foodgrains.

Simulation is carried out using the equations of the model described above. The model is structurally recursive, so that once the initial values are given the procedure is to calculate output, pre-imports availability, imports, marketed quantity, income, and price, in that order. Actual values are used for the initial conditions and for the exogenous variables over the simu-

* not significant at the 95 percent confidence level (one tail).

† the Durbin Watson test is indeterminate at the 95 percent confidence level.

Table 1. Simulated values for production, imports, and consumption, with the inclusion of PL 480 imports, 1956–1964

Year	Production (QFG_t)	Commercial imports (MFG_t)	PL480 imports ($MPFG_t$)	Changes in stocks (ΔGFG_t)	Consumption (QFG_{t-1} $+MFG_t$ $+MPFG_t$ $-\Delta GFG_t$)
1956	73,150	1,394	423	−602	70,522
1957	67,593	1,338	2,914	856	76,546
1958	70,653	1,913	2,040	−269	71,814
1959	72,604	988	3,197	492	74,346
1960	76,786	1,261	4,349	1,403	76,811
1961	80,369	1,111	2,751	−165	80,813
1962	80,025	264	3,036	−355	84,024
1963	85,830	498	4,198	− 22	84,743
1964	89,426	−786	5,586	−1,243	91,873
Totals	696,435	7,980	28,494		711,491

lation period. The impact of PL 480 is assessed as follows:

(1) The model is run over the period 1956–1964 with the inclusion of surplus foodgrains.

(2) A second run is made with omission of the imported surpluses. That is, equations (7) and (8) are replaced by

$$DFG_t = MFG_t + QFG_{t-1} - \Delta GFG_t \tag{7a}$$

$$X_t = QFG_{t-1} - \Delta GFG_t \tag{8a}$$

(3) A comparison is made of the total output for each run in order to obtain an estimate of the impact of PL 480. The figures for total consumption and commercial imports are similarly compared.

Table 1 gives the results of run 1 (PL 480 included). For comparison, Table 2 gives the results of run 2 (PL 480 omitted). The conclusions from the deterministic simulation are that total output over the nine-year period was depressed by 6,783,000 metric tons; commercial imports were reduced by 2,956,000 metric tons; and consumption was increased by 20,004,000 metric tons.

Added realism and a test of the reliability of the deterministic conclusions are obtained by adding the influence of stochastic terms to the simulation. The stochastic terms are not autocorrelated, have zero covariances and means, and have standard deviations equal to the estimated standard errors. In separate experiments errors are alternatively added to the equations (additive errors) and to the estimated coefficients of the endogenous variables (multiplicative errors).

In both stochastic experiments, the procedure is to take a sample of n simulation runs with the omission of PL 480 and calculate separately, for the totals of production, imports, and consumption: (1) the average value, $\overline{X}$, and (2) an estimate of the standard deviation of the sample means, $S_{\overline{X}}$. Ninety-nine percent confidence intervals are applied to determine whether or not the average sample total is significantly different from the deterministic totals obtained in run 1 and run 2 above. The results for $n = 400$ are given in Table 3.

Several aspects of the experiment results are of interest. Perhaps the most striking result of the experiments is the difference in magnitudes of the standard deviations of sample means for the additive and multiplicative errors. The relatively large size of $S_{\overline{X}}$ for the multiplicative errors emphasizes the sensitivity of the model to changes in the endogenous coefficients. On the other hand, the model is not greatly affected by the additive errors from the estimated equations. Also notable is the fact that the addition of the stochastic terms does not add a bias[2] to the deterministic results; that is, none of the generated totals for the stochastic runs is significantly different from the run 2 totals. Finally, the total simulated production with the inclusion of PL 480 is not significantly less than the production without the surplus when multiplicative errors are introduced. However, the increase in consumption is significant. Thus the results discount the importance of the deterministically calculated impact of PL 480 on output and support the calculated increase in consumption.

Application No. 2—Management of Government Stocks of Foodgrains

It has been suggested [2] that if suitable storage facilities had been available over the

[2] Bias is defined as the difference between the deterministic result and the expected value of the stochastic result.

Table 2. Simulated values for production, imports, and consumption of foodgrains in the absence of PL 480 imports, 1956–1964

Year	Production QFG_t	Commercial imports MFG_t	Changes in stocks (ΔGFG_t)	Consumption (MFG_t $-\Delta GFG_t$ $+QFG_{t-1}$)
1956	73,150	1,449	−602	70,154
1957	67,674	1,713	856	74,007
1958	71,275	2,165	−269	70,108
1959	73,297	1,320	492	72,103
1960	77,694	1,732	1,403	73,625
1961	81,617	1,348	−165	79,207
1962	81,038	494	−355	82,466
1963	86,799	908	− 22	81,968
1964	90,675	−192	−1,243	87,850
Totals	703,218	10,936		691,487

Table 3. Summary of results of experiments simulating the impact of PL 480

Type of Experiment	Total production[a] 1956–64		Total commercial imports 1956–64		Total consumption[a] 1956–64	
Actual value	697,747		6,991		713,173	
Deterministic:						
Run 1 (with PL480)	696,435		7,980		711,491	
Run 2 (no PL480)	703,218		10,936		691,487	
Stochastic (no PL480):	$\bar{X}$	$S_{\bar{x}}$	$\bar{X}$	$S_{\bar{x}}$	$\bar{X}$	$S_{\bar{x}}$
Additive	703,145	620	11,107	127	691,322	516
Multiplicative	703,138*	3,975	10,747	473	692,764	3,203

* Not significantly different from the run 1 value at a 99 percent confidence level.
[a] Production and consumption figures do not tally because production affects consumption with a one-period lag.

period 1951–1964, government stocks of foodgrains could have been regulated so that per capita consumption would have remained constant at a tolerable level while total foodgrain imports were reduced. As with the evaluation of the impact of surplus foodgrains, a rigorous measurement of the net benefits of this proposal would require extensive information. For instance, one would be interested in the cost of storage and distribution versus the cost of a program involving the export of surplus crops during bonus years and importation during drought years.[3] However, the essential aspect of the question—whether or not net imports would have been reduced—can be handled through simulation. It is not sufficient to take the actual output and demonstrate that it would have been redistributed through time in such a way that the desired goals are achieved, because the act of redistribution will in itself affect future output through the price responsiveness of farmers and consumers. To obtain an acceptable estimate of the effect of a stock management program on imports, it is necessary to use a market model.

This, then, is what the following simulation attempts to do: to trace the probable effects of a particular controlled consumption program on Indian foodgrains imports and production from 1952 through 1964. In the simulation program, equation (7) is replaced by

$$DFG_t = N_t \cdot V_0(1 + r)^t \qquad \text{(7b)}$$

[3] After I had substantially completed this project, I learned of the current research of Shlomo Reutlinger. Using a specific demand function with a stochastic element, Reutlinger applies a computer program to calculate the changes in consumer surplus and farm revenue as prices and quantities fluctuate. Adding the net gain (or loss) to the direct costs of storage he derives the cost of a hypothetical buffer stock program. It would be a practicable and, I think, informative task to extend the analysis in this paper in the direction of Reutlinger's experiment [4].

where

V_0 is an initial level of per capita consumption, and

r is the rate of growth of V.

Also, the imports equations (3) and (8) are dropped from the model; instead, imports are determined as the residual quantity that would be required to bring consumption to a specified level should production and stocks be inadequate. If production exceeds the per capita consumption restriction, the excess is used to increase stocks. Any excess output remaining after stocks are filled to capacity is exported.

Setting prices, area, and output equal to their actual values for 1951, the initial level of per capita consumption to 170 kilograms, the rate of growth to .005, and the storage capacity to 4,000,000 metric tons, the market is simulated for the period 1952–64. Results are shown in Table 4, and Table 5 gives the comparable simulation values in the absence of a controlled consumption program. The deterministic conclusion is that it would have been feasible to follow the given path of consumption while reducing total imports over the 13-year period by 37,100,000 metric tons.

Following the same procedure outlined previously, multiplicative and additive errors are introduced, and the mean and standard deviation of sample means are calculated for total imports over 400 stochastic runs. The results are set forth in Table 6.

The stochastically generated totals with the stock program are all significantly different from the deterministic totals under actual policies. However, the average total imports for the stochastic runs with additive errors was significantly different from the corresponding deterministic result (run 2) for the operation of the stock program. This was brought about by the introduction to the model of the decision

Table 4. Simulated values for production, imports, stocks, and consumption under a program of regulated per capita consumption, 1952–1964

Year	Production	Imports	Stocks	Consumption[a]
1952	62,230	7,131	0	62,270
1953	61,601	1,454	0	63,685
1954	62,638	3,572	0	65,173
1955	69,915	4,348	0	66,716
1956	74,750	0	1,548	68,367
1957	68,855	−2,193	4,000	70,105
1958	72,825	0	917	71,938
1959	73,655	126	0	73,869
1960	77,527	2,249	0	75,904
1961	80,999	529	0	78,057
1962	81,032	0	651	80,348
1963	87,311	1,015	0	82,698
1964	90,718	0	2,189	85,121
Totals	963,786	18,232		944,250

[a] Average per capita consumption is .175.

Table 5. Simulated values for production, imports, stocks, and consumption under actual policies 1952–1964

Year	Production	Imports	Stocks	Consumption[a]
1952	62,230	3,417	1,330	56,608
1953	62,816	1,964	1,948	64,677
1954	62,709	2,198	1,465	64,812
1955	70,242	1,885	1,667	65,340
1956	75,250	1,542	921	72,385
1957	68,197	3,981	319	78,375
1958	70,643	3,875	1,175	72,341
1959	72,512	4,187	906	74,337
1960	76,745	5,622	1,398	76,731
1961	80,364	3,867	2,801	80,777
1962	80,029	3,301	2,636	84,019
1963	85,833	4,696	2,281	84,747
1964	89,427	4,799	2,259	91,875
Totals	956,995	45,333		967,024

[a] Average per capita consumption is .179.

rules regarding the management of stocks and imports. It is relatively easy to introduce errors into either the equations or coefficients of the basic model; to formulate the difference equation for the dynamic model; to take expected values and demonstrate that the bias is zero. However the introduction of the discontinuities or inequalities associated with the decision rules renders the model intractable to algebra. Thus, stochastic simulation is useful in determining the bias when the algebra is cumbersome or unfeasible. For the present model the bias introduced by the stochastic terms is negative and reinforces the deterministic conclusion that reliance on imports would be significantly lowered by the use of the given stock management program.[4]

I was originally attracted to this analysis by the Raj Krishna article cited earlier [2]. Krishna showed that by redistributing the consumption of actual output through time via stocks it would have been possible to maintain a humane overall level of per capita consumption while significantly decreasing India's dependence on imports. The extension of Krishna's analysis to a market model via simulation was straightforward and, as shown above, the model does not contradict his conclusions. However, there are two aspects of the model that deserve attention.

First, the values for V_0 and r used in the example are arbitrary. They were chosen because they were round numbers which allowed both an acceptable consumption path (from a diet viewpoint) and a decrease in imports. Any number of other paths might have been used, but there is inadequate information in the model to choose among them. Necessary considerations in evaluating a given path include the extent of resource reallocation occurring in response to the generated prices, the value of the consumption stream, and the value of released foreign exchange. The ultimate choice would

Table 6. Summary of results of experiments simulating the impact of a controlled consumption program

Type of experiment	Total imports 1952–64		Total production 1952–64	
Actual value	42,963		963,839	
Deterministic:				
Run 1 (no program)	45,333		956,995	
Run 2 (with program)	23,924		963,786	
Stochastic (with program):	$\bar{X}$	$S_{\bar{x}}$	$\bar{X}$	$S_{\bar{x}}$
additive	17,858†	888	964,326	969
multiplicative	20,501	5,925	959,529*	6,406

* Not significantly different from the run 1 value at a 99 percent confidence level.

† Significantly different from the run 2 value at a 99 percent confidence level.

[4] The implications of the analysis extend to the use of an export-import program to maintain the designated consumption stream. The operation of such a program was simulated by setting stock capacity to zero and conducting the experiments described. The results were very similar to those presented in Tables 4, 5 and 6. A choice between the stock management and the export-import programs would be facilitated by a cost-benefit analysis such as that mentioned in footnote 3.

depend on political feasibility and a planner's conception of community welfare. It is certainly possible that under either of these criteria a path might be chosen that would not result in a decrease in imports.

Second, any intertemporal redistribution program that lowers dependence on imports will by definition also lower average per capita consumption over the program period. Given the distributional problems in India, it is doubtful that a slight general lowering of the average per capita consumption level would be shared equally by the populace. Instead, without offsetting government action the top income groups would maintain consumption, with consumption per person being increasingly affected in inverse proportion to income. Thus the implementation of a controlled consumption program implies the simultaneous implementation of a plan to encourage an equitable distribution.

Summary

A simulation model of the market for foodgrains in India has been applied to two policy questions. With regard to the first question, simulation indicates that the import of 28,000,000 tons of PL 480 foodgrains over the 1957–1964 period depressed slightly the path of production and increased markedly the path of availability. With regard to the second question, simulation indicates that, assuming suitable storage facilities, government inventories could have been regulated over the 1952–1964 period so as to maintain a growth of .5 percent per year in per capita foodgrain consumption from an initial level of 170 kilograms while substantially decreasing total imports over the simulation period.

For each policy question, the stochastic experiments, although producing markedly contrasting paths, substantiated the general results. It was found that the policy conclusions from the deterministic simulation are significant, with the introduction of additive random terms having a standard deviation equal to the standard error of the estimated equations on which the model was based. However, the model is highly sensitive to the introduction of multiplicative random terms, and the simulated depression of production with PL 480 was not significant in the multiplicative experiment. In addition, it was found that the expected value of total net imports under the controlled consumption program was significantly less, compared to the deterministic total, with the introduction of stochastic terms.

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The Transformation of Traditional Agriculture: A Case Study of Punjab, India*

I. J. Singh

THE PURPOSE of this paper is to report the results of a dynamic regional model of agricultural production response, developed and applied to traditional agriculture, which (1) is based on the already tested notions of economic rationality and price responsiveness in traditional agriculture; (2) incorporates several categories of response forces already studied in the case of developed agriculture; and (3) includes in an essential way the features of subsistence production and household-firm interdependence that are central to the study of production response in traditional agriculture. Specifically, recursive linear programming and activity analysis are used to analyze and simulate the production, consumption, and investment decisions of subsistence farmers in a given region. The result is an improved understanding of the process of agriculture in transition and an operationally tested method for projecting future development.

There is growing evidence of the recent transformation of the agricultural sectors of such diverse economies as Israel, Nigeria, West Pakistan, India, the Philippines, Tanganyika, and Thailand [18]. These vast agricultural transformations offer an excellent opportunity to enhance our understanding of the process of development. The purpose of this study was to investigate some of the factors and conditions responsible for one of these transformations, not in its generality, but in great detail.

While agricultural development remains at the center of development theory and policy, only recently has attention been given to the empirical investigation of its role in the LDC's. Though some investigations stress the importance of agricultural exports as a point of departure in the LDC's, the more fundamental problems are those associated with agricultural production response, since agricultural exports, whatever their role, cannot increase without an increase in agricultural production.

A large part of the empirical work done so far on production response in the LDC's touches on a very important aspect: whether peasants in traditional or near-traditional agriculture respond to market opportunities. These studies have shown that agricultural production of specific commodities in specific LDC's is price responsive, especially when account is taken of adjustment lags due to uncertainty and the quasi-fixity of capital stocks. They show that the form and direction of this response is consistent with price theory, so that we can expect market incentives to play an important role in the transformation of traditional agriculture. These empirical findings clearly refute those who believe that cultural and institutional restraints limit to insignificance any responsiveness to market incentives and that the accepted notions of "economic" behavior cannot be applied to traditional agriculture.[1] This study shows that it is possible to explain production response in traditional agriculture within the accepted framework of economic rationality.

There are many detailed elements of production response that have already been incorporated in regional production models. Among these are the interdependence of outputs using common inputs, technological change, changes in yield and acreage components in crop production, uncertainty and adjustment over time, the relative interaction of inputs and output prices, the rates of investments in factors fixed in the short run, the aggregate supply of production inputs, and planned or programmed policy actions [2, 4]. The relevance of these factors for the study of production response in traditional agriculture has not been fully appreciated. It is one of the purposes of this study to correct this shortcoming. In addition it incorporates features of traditional agriculture: "subsistence production" and the critical household-firm interdependencies, a recognition of which is necessary to give a complete picture of production response in traditional agriculture.

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[1] See [1] for references and summary of price response studies in the LDC's.

Activities of a Subsistence Production Farm

The notion of subsistence production

It has long been recognized that the farm combines two fundamental units of microeconomic activity, the household and the firm. The resulting interdependence has been analysed for developed agriculture [2, 5, 10]; but while this is clearly of the essence in the analysis of traditional agriculture, its implications, with a few exceptions, have not been understood. Traditional agriculture is distinguished by the predominance of farms whose main characteristics are (1) the dependence of the household upon the output of the farm to maintain family and animal labor and (2) the dependence of the farm upon the household for its labor requirements. The former determines the degree of subsistence production (commercialization), that is, the proportion of production consumed or sold by the farmer; the latter, the degree to which a farm is a family farm, that is, the proportion of family (or hired labor) in the total labor input on the farm [13].

This interdependence has several implications: (1) Production and consumption decisions are interdependent, since subsistence requirements modify cropping patterns, prevent specialization, and affect the amount and composition of the marketable surplus, thereby dampening response to market profitability; (2) consumption and investments decisions are interdependent since the former, through savings and the marketable surplus, affect cash flows and determine the latter; (3) the availability of family labor plays an important role in the choice of technique, thus determining the composition and amount of investment and the path of technological change. These considerations suggest that in the study of production response in traditional agriculture, an appropriate starting point for analysis is the activity of the subsistence production farm.

The farming household in traditional agriculture can be said to be engaged in a number of general economic activities throughout the year, such as purchasing, production, consumption, sales, investment, and financial activities. These include "traditional" as well as "new" activities which we wish to consider for analysis. Let us examine these activities in greater detail.

Purchasing activities

Purchasing activities include the use of hired labor, animal draft, and tractor hours on the farms in the region. These activities are associated with the use of variable inputs, which may be purchased but are not likely to be unless near-perfect owned substitutes are exhausted (as in the case of labor), or with the use of owned inputs that require complementary cash inputs for their use (as in the case of tractors and animal draft). The use of these inputs depends upon (1) their relative prices, (2) their relative productivities in the alternative uses, (3) their aggregate regional supply, and (4) the availability (existing capacity) of owned substitutes.

Production activities and technological change

Production activities are those that transform owned and purchased inputs into outputs and are measured in acreages sown to important crops in the region. They include: (1) crops grown during two seasons in the cropping year —Rabi (winter) and Kharif (summer); (2) crops grown on irrigated and unirrigated soil conditions; (3) both traditional and new high-yielding crop varieties; (4) crops grown for fodder purposes; and (5) production under two technologies for each crop activity—traditional (bullock-operated) and modern (tractor-operated). These production activities use variable inputs, quasi-fixed capacities, and land of different qualities, and yield final crop outputs measured in yields per acre.

Since crop production is carried out by the performance of agricultural tasks, these are represented by "intermediate production" activities in the present model. Each intermediate production activity has associated with it the use of various inputs, the cost of performing a standard unit of a task, and an intermediate output of a unit of the standard task. The production of final crop outputs then involves the use of several intermediate task outputs by the production activities.

Intermediate production activities provide a quantitative dimension that allows us to view technological change as incorporating (1) the inclusion (or exclusion) of certain agricultural tasks, (2) a change in the way in which tasks are performed, and (3) a change in the level of input use by the tasks. In this manner it is possible to examine the impact of strategic inputs such as water (through irrigation task activities); inorganic fertilizers (through fertilizing activities); the use of new power sources (by incorporating the different ways in which task activities produce intermediate outputs); and the adoption of new high-yield varieties (by considering

them as separate production activities).[2] The process of technological change is viewed not as a replacement of a traditional technology by a new, modern technology but as a task-by-task choice by farmers in the region over time.

Another crucial feature that has to be incorporated is the seasonal use of various inputs, since agricultural operations are time inelastic. A given input available at two different times of the cropping season has to be considered as several different inputs. This feature is included by giving the purchasing activities a time subscript and considering labor, animal draft, and machine capacities during different periods in the cropping year.

Consumption activities

Consumption activities incorporate the nature of subsistence production in terms of the amount of foodgrains and partly processed outputs (sugar) retained for consumption by the household and fodders planted for the maintenance of livestock and draft animals. These consumption requirements are exogenously estimated[3] and are viewed as a constraint in terms of the minimum amounts of certain final crop outputs that have to be grown in any region. Consumption activities have no direct costs, but have opportunity costs in terms of possible profitable crop outputs foregone.

Investment activities

Investment activities are associated with investments in quasi-fixed inputs leading to the replacement and additions to the capital stock. They consist of the purchase of new power sources whose profitability is based upon a net cost calculated on a payback principle [6]. Investments then become profitable if additions to capacity generate enough cost savings in terms of the production or intermediate production activities that use these capacities. Investments also involve a cash outlay for their purchase.

Sales and financial activities

Sales activities involve the sale of marketable surplus for cash when outputs are sold at harvest prices. The cash generated from current sales is then available to meet jointly the requirements of activities in the following year. The decision to sell is viewed as the outcome of two decisions, the decision to produce and the decision to consume out of production with no inventories other than those in the form of crop outputs retained for annual consumption.

The financial activities include (1) a banking activity that allows farmers to "save" excess cash available over cash used at a nominal interest rate which is then available with the accrued interest in the following year and (2) a borrowing activity that allows farmers to borrow working capital at the going interest rate, which then has to be repaid along with the accrued interest in the following year. Other financial cash transactions such as nonfarm cash incomes and cash expenditures for consumption are estimated exogenously and are added to or subtracted from the cash available for the following year.

These activities are incorporated in a recursive programming framework in which decisions are presented as maximizing an objective function each year, subject to a set of constraints that partly depend upon previous year's decisions. The next two sections briefly describe the objective function and the constraint structure.[4]

The Objective Function

The subsistence farmers in a relatively homogeneous farming region carry out their activities with two ordered objectives in mind, the foremost objective being to meet family requirements for food and animal requirements for fodder; once these have been met, to minimize short-run cash costs. This decision rule differs from that of a firm minimizing cash costs in three instances: (1) The first-order consumption requirements act as a constraint upon cost minimization; (2) the use of family labor is given a zero cost in the function, its annual costs of maintenance being fixed; and (3) the use of animal draft includes only variable costs (concentrates and additional fodder given when animals work), since annual maintenance costs are also fixed.

The cost coefficients for the objective function include the variable cash costs for labor hired (if any), tractor hours used (fuel and other costs), and animal draft used (variable cash costs) for the purchase activities; the costs

[2] For a detailed exposition of the notion of intermediate outputs, standardized agricultural tasks, and technological choice, see [17]; to see how these are incorporated into a regional programming model, see [16].

[3] The main determinants of the consumption of subsistence crops were found to be the size of the household and the amount of the output of the crop [15].

[4] For a detailed exposition of the model, see [16].

of seeds and manure for the final production activities; the costs of performing a given standard task for the intermediate production activities; costs estimated on a payback principle for the investment activities; harvest prices of crop outputs for the sales activities; and the appropriate interest rates for the savings and borrowing activities—all lagged one year to represent simple price expectations on the part of the farmers.[5]

The Constraint Structure

The constraint structure includes three broad categories: (1) resource constraints, (2) behavioral constraints, and (3) financial constraints.

Resource constraints

Resource constraints include constraints upon the regional availabilities of (1) variable inputs such as family labor, hired labor, fertilizers, and animal draft; (2) quasi-fixed inputs in the form of available capacities of various power sources such as tractors, tubewells, threshers, cane crushers, which change with both investments and physical depreciation; and (3) fixed inputs of various qualities of land and the amount of canal irrigation available in the region.[6] The strong seasonal use of inputs is accounted for by considering labor, animal draft, and quasi-fixed capacities during seven different periods in the cropping year, while land and canal irrigation availabilities are considered for the summer (Kharif) and the winter (Rabi) cropping seasons.

Behavioral constraints

Behavioral constraints describe the elements of response to uncertainty, adjustment through time, adoption, and learning behavior that modify the response to economic opportunity, and include three broad categories: (1) flexibility constraints, (2) adoption constraints, and (3) consumption constraints.

The flexibility constraints place both an upper and lower limit on the extent to which subsistence farmers are willing to change their output of any given crop in response to profitability in any one year. This cautious response to changes in profitability may be due to (a) expectations that the changes may be short-lived; (b) a desire to diversify crop portfolios to avoid risk, given the nature of subsistence. Flexibility constraints express the farmer's response to risk and uncertainty and can also be viewed as an approximation of a nonlinear objective function in a linear model.[7]

The adoption constraints account for the fact that when a new activity is introduced, even if it is profitable and remains so, it is not adopted immediately. Both the investment in new power sources and growth in the acreage of new crop varieties are constrained by an upper limit to express factors such as learning, experience, cautious behavior, and innovative leadership. The adoption constraints describe an s-shaped path and depend recursively upon the previous year's level of adoption. Such adoption paths are not peculiar to traditional agriculture but are also evident in modern agriculture and industry [6, 11].

The consumption constraints describe the limitation imposed by the need to produce family and livestock requirements on a subsistence farm and are included in the form of lower constraints upon the amount of output for certain crops.[8] These consumption constraints are peculiar to subsistence agriculture and limit specialization and response to market profitability.

Financial constraints

Financial constraints are of two types: (1) an upper limit upon the total amount of short-term working capital available from various sources and (2) the constraint upon cash available for carrying out the activities that use cash by the total cash generated in the previous year through sales, savings, and nonfarm cash incomes, less any cash consumption expenditures and the repayment of previous years' borrowings of working capital.

Model Summary

The model is computed by setting up a linear programming problem for a given initial year and a solution that maximizes the objective function obtained. The results from this solution are then used to estimate a new set of con-

[5] The use of a more complete price expectation model is also possible and is under investigation.

[6] Canal irrigation is an example of fixed regional resources available to farmers that can be changed by policy decisions with regard to infrastructure.

[7] For the use of flexibility constraints, see [4], [12], and [14]; for a theoretical justification of their use, see [3].

[8] This is only one way to include subsistence production. An alternate formulation involving a recursive dependence on endogenous levels of outputs and incomes generated by the model is being investigated.

straints for the objective function, constraints that depend recursively upon the previous year's decisions; and along with exogenous information on input and output prices, the problem is set up for the next year and new objective function maximized. Certain activities and constraints are introduced only when they become available to farmers in the region (such as new varieties, inorganic fertilizers, and new power sources).[9]

Summary Results for Central Punjab, India (1952–1965)

The tremendous growth during the past two decades in total output and productivity in East Punjab (India) and especially the central five districts—Central Punjab—has been widely and repeatedly reported [7, 8, 9]. What has not been reported are the tremendous structural changes that have accompanied this growth and have slowly but surely transformed the traditional agricultural economy. The r.l.p. model described here has made it possible to explain precisely this structural transformation in terms of the economic variables and the environmental conditions that operate at the farm level.

During the 14 years for which the model was computed, four aspects of this transformation are clearly delineated: (1) investments in new power sources; (2) the consequent change in farm technology; (3) structural shifts in labor use; and (4) commercialization of the subsistence production sector. These results are now briefly reviewed.[10]

Investments in new power sources

The traditional inputs of peasant agriculture, labor and animal draft, are being complemented by the use of new power sources. Tremendous investments in tractors, tubewells, and power threshers are predicted by the model and are partly shown in Figure 1. According to the model, the number of tractors in use has increased sevenfold, the number of tubewells in use nearly twelvefold, and the number of threshers over fourfold, even though the last were introduced only in 1963. Investments in power cane crushers increased between 1952 and 1955; but no additional investment occurred again until 1959–60, after which investments again fell to zero. The index of use showed a similar trend, with an increase in the first three years followed by a continual decline almost to zero by 1965. This indicates that the adoption of labor-saving power sources has not been across the board and that in some cases their use has actually declined. This has a bearing on the choice of technique, since power cane crushers are profitable to use only when labor has to be hired during the period of cane crushing (November to March). With the growth in population and availability of family labor and a decline in the total amount of cane crushed, there has actually been a reversal in the adoption of labor-saving technology and the mechanization of this task.

Change in farm technology

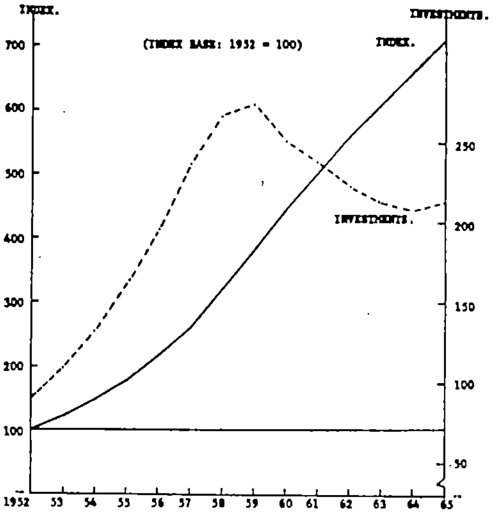
The investments and the use of new power sources predicted by the model show that the trend in mechanization does not lie on a balanced growth path. The choice with regard to technique is made task by task. During the period studied, this choice led to an investment pattern oriented towards the performance of specific tasks—tractors for land preparation, sowing, and transportation; tubewells for irrigation; and threshers for threshing.

Figure 1 shows the indices of total gross area sown, and Figure 2 shows total standard units of land preparation, irrigation, cane crushing, and transportation used in the region, and the indices of the performance of these tasks by labor-saving technologies along with the percentage of the total task use mechanized (1952 is the base year).

The index of the total gross area sown has increased by 37 percent in the period, but the index of area sown by tractors has increased by 363 percent while the percentage of total gross area sown by tractors has increased from 7.7 percent in 1952 to 25.6 percent in 1965. The indices of total land preparation, irrigation, and transportation increased by 46 percent, 39 percent, and 396 percent, respectively, while the indices of the performance of these tasks by mechanized means increased 384 percent, 501 percent, and 336 percent, respectively. The percentages of land preparation and irrigation performed by mechanized means increased from 11.3 percent to 37.3 percent for land preparation and from 15.8 percent to 68.3 percent for irrigation from 1952 to 1965, in the latter case totally replacing the traditional Persian wheel as a means of irrigation by tubewells. The in-

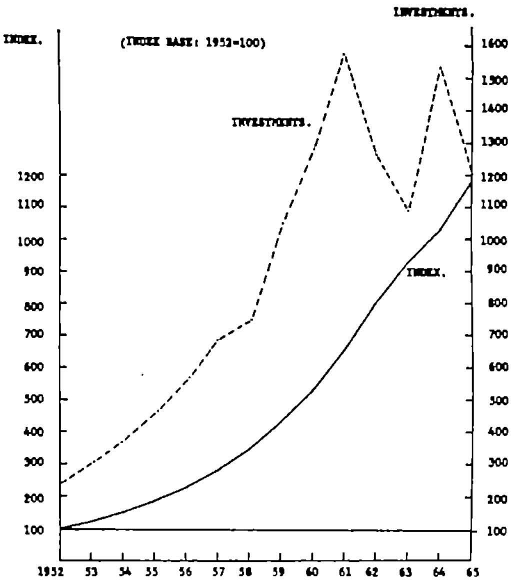
[9] For a detailed exposition of the methodology of recursive linear programming, see [4].

[10] For details, see accompanying charts; for detailed model results, see [16].



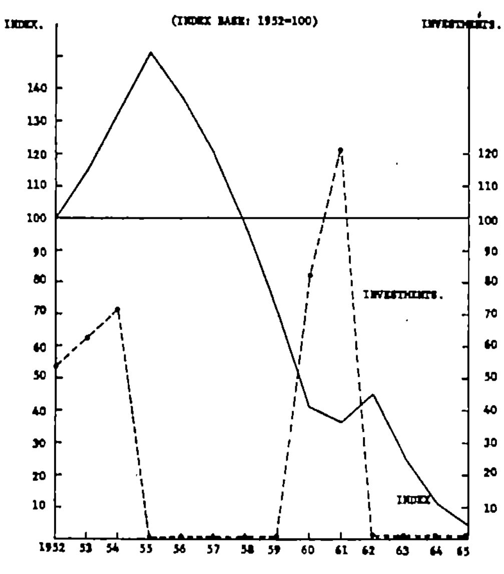
INDEX OF NUMBER OF TRACTORS IN USE & ANNUAL INVESTMENTS IN TRACTORS (NUMBER PURCHASED) IN CENTRAL PUNJAB. (1952 - 1965).

SOURCE: MODEL RESULTS.



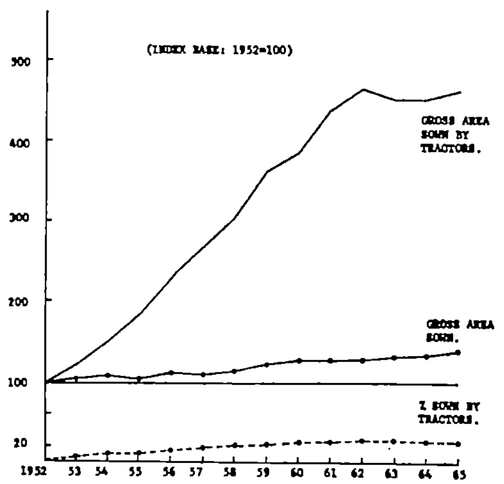
INDEX OF NUMBER OF TUBEWELLS IN USE & ANNUAL INVESTMENTS IN TUBEWELLS (NUMBER PURCHASED) IN CENTRAL PUNJAB. (1952 - 1965).

SOURCE: MODEL RESULTS.



INDEX OF NUMBER OF DIESEL POWERED CANE CRUSHERS IN USE & ANNUAL INVESTMENTS IN POWERED CANE CRUSHERS (NUMBER PURCHASED) IN CENTRAL PUNJAB. (1952 - 1965).

SOURCE: MODEL RESULTS.



INDEX OF GROSS AREA SOWN & GROSS AREA SOWN BY TRACTORS AND GROSS AREA SOWN BY TRACTORS AS A PERCENTAGE OF TOTAL GROSS AREA SOWN IN CENTRAL PUNJAB. (1952-1965).

SOURCE: MODEL RESULTS.

FIGURE 1

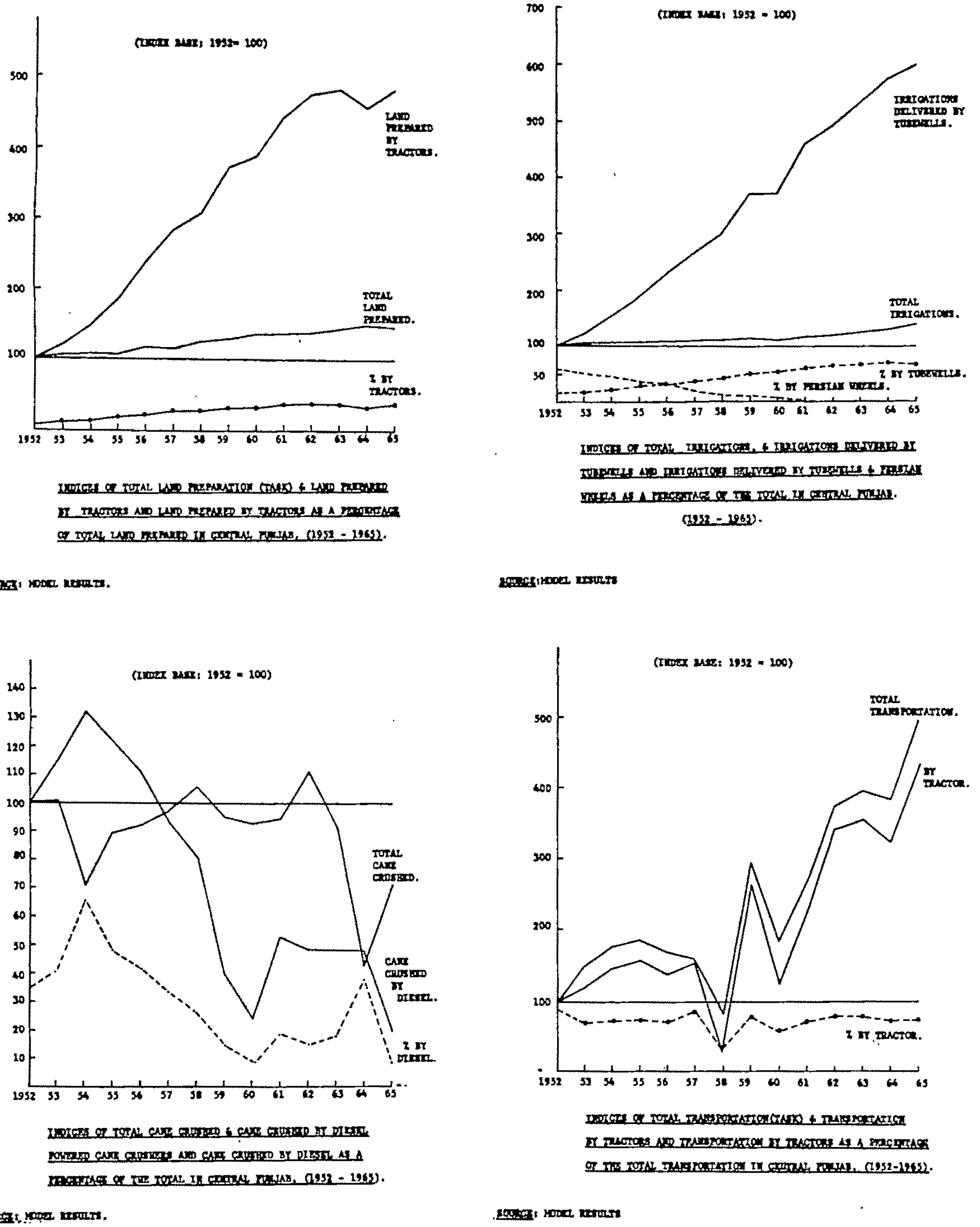


FIGURE 2

dex of total cane crushing declined, as less sugarcane output is being processed on the farms and more being taken to sugar mills; but the percentage of cane crushed by diesel declined from 35 percent in 1954 to 5.2 percent in 1965.

To summarize, the pattern of change in farm technology predicted by the model indicates that technological change is task oriented; that it does not consist of the total replacement of a traditional technological set (bullock-labor intensive technology); that it consists rather of

a task-by-task replacement leading to a period of transition during which labor-saving and labor-using technologies continue to be juxtaposed in a "hybrid technology" whose components depend upon the detailed cost structure of operations and whose proportions change over time.

Annual and seasonal labor use

Figure 3 shows the index of total annual labor use predicted by the model along with labor use in selected periods of the cropping year. Total labor use declined from 1952 to 1961, during a period of growth in output due to the adoption of labor-saving technologies, but has shown some increase from 1962 to 1965 because of an increase in total output at an even higher rate. Annual labor use as a percentage of total labor available declined from 63.4 percent in 1952 to 48.6 percent in 1962, but increased to 54.4 percent by 1965. Similarly, annual labor use as a percentage of family labor available declined from 82.2 percent in 1952 to 63 percent in 1962, but increased to 70.5 percent by 1965. Using the often misused measure of "labor surplus" on the basis of annual availabilities, anywhere from 52 to 36 percent of the total labor and 37 to 17 percent of the family labor is "surplus" in the region. The problem with this measure is that it does not take account of the seasonal distribution of labor use.

When labor use is examined during different periods in the cropping year, the model projects a far different picture. The index of labor use increased substantially for some periods (during the periods of summer land preparation and planting, winter harvesting, and transportation), increased only moderately in others (during the period of summer irrigation and winter planting), but declined substantially in others (during the periods of summer harvesting, winter irrigation, and sugarcane harvesting and processing), even though total output and acreage sown increased substantially. (Figure 2 shows indices for period V (winter irrigation) and period VI (winter harvesting) and for total annual labor use.)

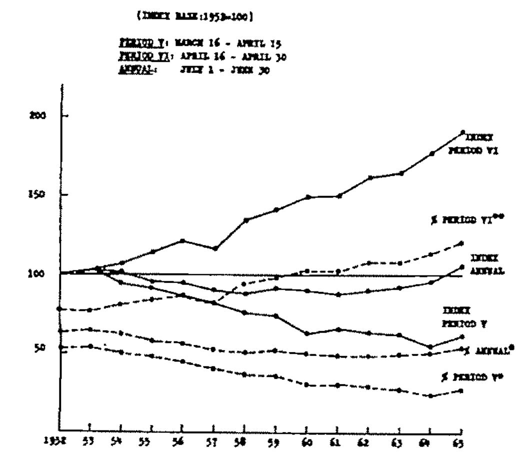
If we examine seasonal labor use in relation to total and family labor availabilities, we do not get the same results as those predicted by annual labor use. The model shows labor is "very scarce" in some periods, "occasionally scarce" in others, "slack" in some, and "very slack" in others, when measured in terms of the amount of family labor available in any period. In periods when labor is very scarce and family labor is exhausted, labor has to be hired in order to perform the tasks. This seasonal scarcity explains in part why technological change is task oriented and why mechanization occurs in an apparently labor-surplus economy. Though the demand for total labor has increased only slightly, changes in the cropping patterns and the technological mix have brought about a structural shift in the demand for labor in the region. Not only have seasonal labor shortages brought about technological change in some cases, but in its turn technological change has allowed an increase in total output and resulted in an increase in the demand for labor in some periods that would otherwise not have been possible. In the period of transition, mechanization per se does not imply a reduction in the demand for labor.

The commercialization of traditional agriculture

The growth in total output and productivity in the last two decades, which has been accompanied by increasing mechanization, changes in farm technology, and structural shifts in the demand for labor, has also been accompanied by an increasing commercialization of the agricultural sector and a shift away from subsistence production. This increased participation in the market economy is predicted in the model by (1) an increase in both the amount and the percentage of the marketed surplus for major crops in the region and (2) an increase in the use of nonfarm inputs.

Figure 3 gives the indices of total production, marketed surplus (sales) and consumption of wheat and sugarcane from 1952 to 1965 predicted by the model.[11] The index of the production of wheat increased by 14 percent and the index of sales increased by 273 percent, while the index of the consumption of wheat remained fairly constant. The marketed surplus of wheat as a percentage of total production increased from 53.4 percent in 1952 to 80.3 percent in 1965, indicating that whereas 47 percent of the production of wheat was for subsistence in 1952, only 18 percent of the production was for the same purposes in 1965. The predicted results for sugarcane are more dramatic, for while the index of production increased by 138 percent,

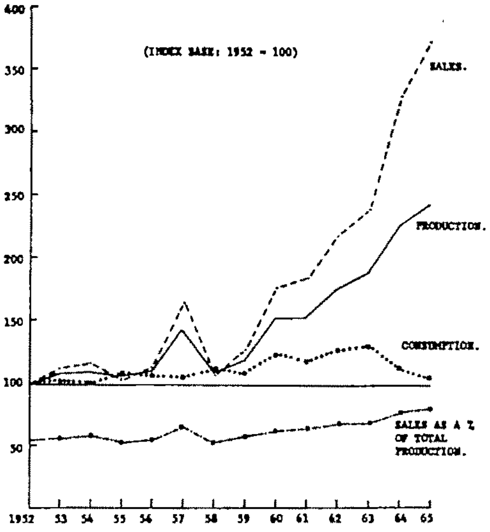
[11] The model included all major crops in the region—wheat, gram, barley, winter fodders, maize, rice, groundnut, cotton, millets, and sugarcane.



INDICES OF ANNUAL & SEASONAL LABOUR USE & LABOUR USED AS A PERCENTAGE OF TOTAL & SEASONAL LABOUR AVAILABLE IN SELECT PERIODS IN CENTRAL PUNJAB, (1952 - 1965).

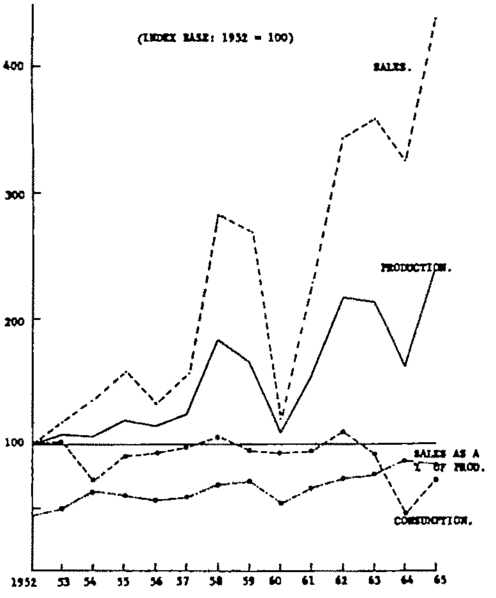
* ESTIMATED ON THE BASIS OF AN 8 HOUR WORK DAY.
** ESTIMATED ON THE BASIS OF A 10 HOUR WORK DAY.

SOURCE: MODEL RESULTS



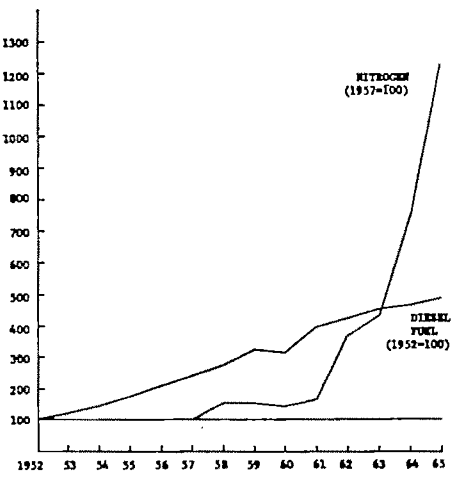
INDICES OF TOTAL PRODUCTION, MARKETED SURPLUS(SALES), & CONSUMPTION AND SALES AS A PERCENTAGE OF TOTAL PRODUCTION OF WHEAT IN CENTRAL PUNJAB, (1952 - 1965).

SOURCE: MODEL RESULTS



INDICES OF TOTAL PRODUCTION, MARKETED SURPLUS (SALES), & CONSUMPTION & SALES AS A PERCENTAGE OF TOTAL PRODUCTION OF SUGARCANE IN CENTRAL PUNJAB, (1952 - 1965).

SOURCE: MODEL RESULTS



INDICES OF TOTAL ANNUAL CONSUMPTION OF DIESEL FUEL (BY TRACTORS & DIESEL ENGINES) AND NITROGENOUS FERTILIZERS IN CENTRAL PUNJAB, (1952 - 1965).

SOURCE: MODEL RESULTS

FIGURE 3

the index of sales increased by 336 percent, the percentage of sales to total production increased from 45.5 percent in 1952 to 83.5 percent in 1965, and the percentage of subsistence production dropped from 55.5 percent to a bare 16.5 percent—a tremendous shift towards production for the market. The index of consumption of sugarcane in the form of processed gur (brown sugar) actually declined from 100 in 1952 to 72 in 1965, showing a substitution of factory sugar in the diet. Similar results were predicted for all the major crops—maize, rice, groundnut, and cotton (American).

With an increase in the use of tractors and diesels as power sources, the total consumption of diesel fuel increased nearly five fold from 11.4 million litres in 1952 to 55.5 million litres in 1965 (Figure 3). At this rate of growth in consumption, in the years to come the availability of petroleum products could act as a serious constraint upon the adoption of these power sources, since India is short on petroleum resources and has to import them.

Another component of the increased use of nonfarm inputs predicted is the increase in the consumption of nitrogenous fertilizers, whose consumption increased twelvefold (Figure 3) from a mere 1.6 million kilograms of nutrient equivalents of nitrogen in 1957 to 20.4 million kilograms in 1965; and the demand is insatiable at currently subsidized prices, with the increased adoption of new varieties and increased use of water. The model showed that the only constraint upon the use of nitrogenous fertilizers was their total availability.

Conclusions

These substantial structural changes in investment patterns, farm technology, labor use, and market orientation predicted by the model, along with the unprecedented increases in total output, have spelled the content of the green revolution in the Punjab. The model is based on the assumption of rational economic behavior and uses the standard tools of economic analysis to generate the past development of the agricultural sector in a selected region, and is able to explain observed phenomenon of the transformation process. It is reasonable to expect that the model will also be capable of projecting possible future transformations under alternative policy assumptions.

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The Green Revolution and the World Rice Market, 1967–1975*

E. Ray Canterbery and Hans Bickel

The dramatic green revolution in rice, wheat, and corn may shift economic development problems from concern with widespread starvation to concern with a potential grain glut on world markets. This unexpected technological twist foreshadows possibly some new trading difficulties for developed agricultural exporters such as the United States, Japan, and Canada plus some entirely different kinds of problems for LDC grain consumers and producers. The history of the development of the new seeds and the precise nature of the new technology has been widely discussed elsewhere (see, e.g., [1]). Barring widespread war, one realizes that what happens in terms of LDC production of rice and wheat and developed nations' responses will for the most part determine the economic destiny of the less developed world in this decade.

Methodology

Because of the sharp change in technology, many official government forecasts for grain output and trade patterns through 1975 are in error. The purpose of this paper is to attempt to remedy these difficulties by taking *explicitly* into account the yield changes from the technological advance and the impact of both production and consumption changes on the price of rice in the major producing nations and in the world.

Rice consumption and production estimates were developed both from statistical equations and, in the case of production in the miracle-grain-adopting nations, from nonstatistical techniques.[1] It was possible to estimate statistically rice demand functions for the major consuming nations and for the world because of the stability of most of the consumption functions. Two sets of equations were run for rice consumption (C_r) for each of the major nations: (1) Explanatory equations meeting relatively high statistical standards were estimated for the purpose of calculating income and price elasticities; (2) forecasting equations were developed that met only the test of "best fit." The same criteria were applied to production estimates.

The estimation for production and related elasticities was more difficult. We were in part constrained either by data availability or by the research costs of building data series for all the potential determinants of output. We were able to develop data series on total fertilizer consumption (F), total production (Q), area in hectares used in rice production (A), and various price series for 1955–1966, the period used for the regressions. We knew that irrigation expansion, labor input growth, insecticide usage, and rainfall variation would in some cases strongly influence output. As it turns out, the "package" nature of the miracle grain technology causes fertilizer usage, irrigation, and insecticide use to increase at about the same rate. In addition to their reduced sensitivity to the length of days and their early maturity, the new varieties experience diminishing returns from fertilizer application at much higher yields than the old, local varieties. Hence, the effect of the new technology can for the most part be "embodied" in fertilizer consumption in the LDC's. This of course is not true for the DC's. In the nonequation estimates of output in miracle-grain-using nations it was possible to take into account most of these factors.

The countries individually selected for both rice consumption and production analysis are those that are currently important in terms of quantities produced and/or consumed plus those having substantial potential. The statistically used consumption definitions by country depend upon the nation's rice trade balance during the observed period. For the importing nations of India, Japan, the Philippines, and Malaysia, consumption equals production plus imports. For the exporting nations of Burma, Thailand, Brazil, and the United States, consumption equals production minus

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[1] The statistical parameters, t-values, coefficients of multiple determination and variation, von Neumann ratios, and the nonstatistical production estimates are available on stencils from Professor Canterbery.

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exports. South Korea and Pakistan are intermediate cases, while West German consumption equals her imports. Because of data limitations, one important nation is excluded—Mainland China—while only consumption estimates were made for Indonesia and Vietnam. Mainland China and Indonesian consumptions are discussed in terms of UNFAO projections.[2]

There is not sufficient space to detail herein all the econometric designs for the statistical estimates.[3] A formal theory of expected relations was postulated prior to conducting the final empirical tests. It was hypothesized that rice consumption is related to income, prices or relative prices, and population. Because of multicollinearity, it is necessary to combine GNP and POP into one variable in the *explanatory* equations. In addition to linear forms, log, inverse log, and semilog transformations are used to capture the actual pattern of behavior of the variables over time. A dummy variable is used for extreme observations or large function shifts. In the world equations, for example, a dummy variable is used for the 1958 dependent variable observations which apparently were affected by the Suez crisis. (Overall, the dummy variable is used sparingly.) In all consumption equations the *current period* price is used. In a few cases in which multicollinearity was biasing the "explanatory" coefficient estimates, the nominal (P_r) rather than the relative (or real) price (P_r/CLI) is substituted. In most of the LDC's there is no identification problem with price, as output depended upon price lagged. There was, however, a price-simultaneity problem in Japan and Thailand, and a simultaneous solution was required.

Preliminary statistical tests suggested a high correlation between area and fertilizer consumption in most nations. Also, in tests with these two variables and relative price (lagged one year) against Q_r, the price variable was usually statistically insignificant. A number of random variables, weather variation being one, influence agricultural output. In part this explains the often low degree of linear correlation between output and time. There is also a lag between commodity price changes and changes in output, because it usually takes a new growing season for commodity price-induced input changes to affect production. This lag is sometimes shorter in developed nations and will become shorter in the LDC's as the area that is doubled-cropped increases. As a result of these considerations both current and lagged observations of the independent variables appear in the production equations; area and yields usually are estimated in separate equations, and subsequently their estimated values are multiplied $[\hat{A}_r \cdot (\hat{Q}_r/\hat{A}_r)]$ to gain production estimates. As (Q_r/A_r) involves a function of a function, two-stage least squares (2SLS) is used in estimating yields. This specification has the further advantage of avoiding biases from multicollinearity resulting from the necessity of leaving out correlated variables.

Where no identification problem exists (price lagged in production equation), the explanatory price parameters are estimated directly by classical least squares. Then elasticities, with price as the dependent variable, can be determined by solving for price in each set of supply-demand equations. However, in those nations where both current supply and current demand determined price in an identified model, a simultaneous estimation is used. The reduced forms of these equations can be derived by solving the equations simultaneously in terms of P/CLI and in terms of C. The statistical parameters can then be estimated indirectly from the reduced form equations. Where the equations are simultaneous and not perfectly identified, we use 2SLS in estimating parameters.

The reliability of the elasticity estimates (from "explanatory" equation estimates) is not affected by multicollinearity but possibly is affected by small sample sizes. The standard errors are not biased by autocorrelation, but elasticities are biased where derived from nonlinear equations. The direction of bias from the latter source cannot be determined, but because of the "ball park" nature of the estimated elasticities the errors are believed to be relatively small.

Statistical forecasts of production at 1966 prices lead to underestimated output values in those nations adopting the miracle seeds after 1966. In such countries nonequation production estimates are initially made at assumed 1966 prices. The final projections "marry" the statistical forecasts, the elasticity estimates, price changes, and the nonequation forecasts of production.

Forecasting production and consumption at varying prices is of course most difficult; and for some nations such forecasts are not possible

[2] A summary of data sources follows: production and area, [2, 3, 4]; trade, [6]; prices, [2, 3, 5]; fertilizer, [3]; stocks, [7]; GNP, [8]; population, [7].

[3] These details also are available upon request, pending their publication.

because of unreliable price elasticity estimates. Only price-constant forecasts are provided for such nations. The process whereby estimated input-price and consumption-price elasticities are applied to the price-constant forecasts is explained in a later section.

Limitations of Purely Statistical Estimates

The listing and evaluation of certain assumptions that apply to our statistical forecasting equations perhaps describe best the limitations of the statistical part of this study.[4] In certain cases the least-squares estimates were adjusted "by hand" to account for known divergencies between the statistical path and the actual path of the dependent variable. For example, where per capita consumption has reached a "maximum" level in DC's during the estimation period, the consumption equation tends to overestimate projected consumption.

It is assumed that:

(1) The usual least-squares assumptions apply to the *initial* forecasts from the equations. Of course, the main divergence from the least-squares path for production is expected to be caused by the adoption of new technology, and this is taken care of in the nonstatistical estimates for those countries in which it is expected.

(2) Unless otherwise specified, any extremely adverse weather conditions dominating any particular year will be offset by extremely favorable weather conditions in some other year.

(3) The prices of nonlabor inputs averaged during the forecasted period values are equal to their observed averages. Because of more intensive cultivation of land in the IRRI-adopting countries, the long-run price of capital may rise relative to the price of land and labor. Such relative factor price changes, however, are not expected to have any appreciable impact prior to 1975.

Labor costs are in part accounted for in the cost-of-living index used as a commodity deflator. Hence, changing labor costs are in part taken into account in the nonconstant price forecasts. Although the new varieties are both labor- and capital-using, they are at the margin more capital-using than labor-using.[5]

(4) Labor inputs will grow at a sufficient rate to allow the expansion of the implied potential associated with land, capital, and technological availabilities.

(5) The rate of double-cropping of *local* varieties will not change through 1975. This is highly probable, as double-cropping normally can occur only on irrigated land and most of the new irrigated land will be devoted to the new higher-profit miracle grains. This potential increase in double-cropping is taken into account in the nonstatistical estimates.

(6) There will be no major war in the Far East or Southeastern Asia prior to 1976.

(7) Increases in irrigation are either proportional to the increased area cultivated or are highly correlated with a time variable.

(8) Mechanization has not had a significant impact on rice production.

(9) Current aid, government programs, and policies affecting agriculture and trade in rice in all nations will not change. *This assumption, however, can be relaxed when we make a choice between estimates of production at the various assumed price changes.*

Estimated Price Changes and Production Behavior

Price data

The most frequently used price for both the demand and the supply equations is the milled wholesale price of rice, which in most cases is highly correlated with the retail price. It is believed, however, that in many cases the milled wholesale price may generate better statistical results with the supply equations than with the demand.[6] In all cases "free market" prices are used; that is, the price series selected for each nation is one of varying nominal prices. Beyond this the selection criterion is one of data availability.

In constructing real prices, we divided the nominal price by a cost-of-living index (CLI), an agricultural retail price index, or an agricultural wholesale price index. In some cases there was very little difference in the results irrespective of which index was used, but in general the cost-of-living index gave the best statistical results in both the demand and supply equations. Consequently, the cost-of-living index is used in the final estimating equations.

[4] The extra nonstatistical assumptions are also available upon request, with the nonstatistical tables.

[5] Over time, of course, this increased relative demand for capital may increase the price of capital and in the longer run may moderate expansion of IRRI 8 production.

[6] The following exceptions apply: the husked producer price is used for Japanese production *and* consumption; paddy producer for U. S. supply; paddy wholesale for Thailand and Brazilian supply; the export (to Ceylon) price for Burmese demand and supply; and the averag unit value of export for world production-consumption.

Table 1. Estimated rice consumption elasticities from structural equations[a] (at 1966 observations for nonlogs)

Nation	With respect to C_r				With respect to C_r/POP	
	GNP/POP	P_r/CLI	P_r	GNP	GNP/POP	P_r/CLI
Japan	.107	0				
United States				1.98	0.86	0
India	1.33	0				
Pakistan	7.14	3.85				
Thailand	−3.96	0				
Burma	−3.46	0	−4.40		−6.42	−3.68
South Korea	1.15	0				
Philippines	4.00	0				
Malaysia	1.27	−.89				
Brazil	2.47	0				
West Germany			0	.89		
World total	1.00		−0.50[b]			

[a] The algebraic signs of the elasticities are taken from the signs of the slope coefficients; hence a positive sign for price suggests perverse elasticity. With the exception of Pakistan, all estimates are based on equations having statistically insignificant multicollinearity. Where the price coefficient is not significant and other statistical requirements are met, perfect inelasticity is inferred.

[b] This elasticity is with respect to the world *trade* (unit value of exports) price.

Price-change estimates

Although production and consumption elasticities can be estimated from the structural explanatory equations, the current period price of rice itself is an endogenous variable, being determined simultaneously by output and consumption. Therefore the impact of the same independent variables on the price of rice is estimated by solving the supply and demand equations simultaneously for current price (except where an identification problem exists). The structural elasticity estimates appear in Tables 1 and 2; the simultaneous estimates appear in Table 3. These structural and simultaneous elasticities (where reliable) provide sufficient information to estimate price changes and subsequent production and consumption adjustments from their 1966 constant price values.

The simultaneous price elasticities are based on "final" production and consumption adjustments that have occurred as prices change. In some years in some countries the nominal price of rice is fixed at a support level for the producer or at a ceiling for the consumer. But as we move from price elasticities to estimates of price changes in those nations using government market intervention, these are the price changes that will occur as such price supports or ceilings are removed. It is of course possible and *even probable that the governments' prices will not be removed prior to 1975. In those cases the constant-price production forecasts apply.*

Forecasts of the independent variables through 1975 were made in order to estimate price changes. The "free market" estimates in Table 4 are derived by multiplying the expected annual percentage change in the independent variables—per capita income, area, fertilizer, lagged price—by their respective simultaneous elasticities with respect to current period price (from Table 3). The lagged-price variable reflects the normal "cobweb" relationship among consumption, production, and price. The price

Table 2. Rice production elasticities from structural equations[a] (at 1966 observations for nonlogs)

Nation	Elasticity definition					
	Q.A	Q.F	Q.P	(Q/A).F	F.P	A.P
Japan	0	.435	1.35*	.207	.440(−1)	
United States	1.06	.443	0(−1)	.089	−.056(−1)	0
India	3.19	.213			1.23	
Pakistan		.220(−1)		.207		
Indonesia	1.05			.007		
	0.20	.007	.061*(−1)	.016		.035(−1)
Thailand	.402		.318*	1.96		
Burma	1.04	.187	.035(−1)	.550	.150(−1)	0(−1)
South Korea	.853		.542*(−1)	1.97	.334	
Philippines			.086*(−1)			
	.169	.203	.371(−1)	.026	.113(−1)	0(−1)
Malaysia	.200	.374	0(−1)		0(−1)	
Brazil	1.06	.500	0*(−1)			
World	.93	.282			.179**(−1)	

[a] The coefficients of lagged independent variables are denoted by (−1) following the coefficient. All estimates are based on equations having statistically insignificant multicollinearity. Zero elasticity estimates are given only when the equation meets rigorous statistical tests and additional information supports this inelasticity presumption. The first letter in each case represents the dependent variable and the second the independent variable. "Q.A" is, for instance, response of output to changes in area (hectares harvested). The year 1966 was chosen as most representative for forecasting through 1975.

* Indicates that price is in real terms.

** The world price equals the unitary value of world rice exports.

Table 3. Rice price elasticities, simultaneous estimates[a] (at 1966 observations for nonlogs

Nation	P.(GNP/POP)	P.GNP	P.A	P.F	P.P (−1)
Japan	.964		.0000039	−3.92	
United States	1.45		−1.78	−.745	−.111
India	11.46		−30.19	−1.81	−.102
Thailand	.110		.110		
Burma[b]		−.787	2.96(−1)	−.421(−1)	.003
South Korea	29.30		−27.00	−18.32	−7.16
Philippines	9.34		−.433	−.520	−.953
Malaysia	1.42		−.220	−.410	−.010
Brazil	31.27		−13.42	−6.33	.139
World	2.15		−1.00[c]	−.230	−.040

[a] All elasticities are derived from solving at least two equations simultaneously (at least one demand and one supply). Where the price coefficient was insignificant but of positive sign, we assumed its actual sign was negative in order to retain the appropriate signs for various elasticities. These are shift elasticities that indicate the responsiveness of equilibrium prices to independent variable changes. Three nations are excluded: Complete estimates were not available for Pakistan; we have no consumption equation for Indonesia; West German production is so small that no output estimates were made.
[b] Nominal price is substituted for real price.
[c] No direct estimates of the aggregate responsiveness among area, output, and price was made. This estimate is based on major-producing-nations results.

changes forecasted from changes in per capita income, area utilized, and fertilizer demand will themselves have an impact on production.

In general, those nations having either price supports or price ceilings can be identified by the sign of the estimated net annual change in price. There are, for instance, price ceilings in South Korea and in Brazil where price changes are estimated as positive. All the "free market" price-change estimates (Table 4) suggest only what price changes *would be* if no nations adopted the new varieties. Not all of these estimates are viewed with the same confidence.[7]

The introduction of the new miracle grains increases output substantially. We know that, other things being equal, such output increases would reduce rice prices in the particular country. Of the current miracle-grain adopters, a complete set of elasticity estimates for post-miracle-grains free market estimates of price changes through 1975 could be generated only for India, the Philippines, Brazil, and from the world equations (Table 5). Because of the difficulty of shifting resources into alternative employment in less developed nations, we assume that in fact there would be a downward stickiness in output changes in response to price declines. The positive responses to upward price movements have been supported by government assistance and persuasion in most LDC cases. For simplicity we assumed throughout that the responsiveness on the downside would be only half as great as on the upside of price changes (the semiresponsiveness category). Except for this qualification, these estimates are derived in the same way as those in Table 4.

[7] In the Burmese equations income and area are highly correlated. The effect on prices of changes in fertilizer inputs is probably accurate. But the impact of changes in area planted is of the wrong sign. This effect is probably counterbalanced by the very small indicated impact of the lagged price. In short, while the price change attributed to area is probably incorrect, the net annual change may be very close to the true figure.

Table 4. "Free market" estimates of price changes (without miracle grain impact), 1967–1975[a]

	Japan	United States	India	Thailand	South Korea	Burma[c]	Philippines	Malaysia	Brazil	World
Average annual price change percentage attributed to changes in:										
Per capita income	5.48	3.92	22.23	.404	61.53	−3.54	13.64	1.86	56.29	4.79
	[5.48]	[2.7]	[1.9]	[4.1]	[2.1]	[4.5]	[1.5]	[1.3]	[1.8]	[2.2]
Area	—[b]	−2.65	−39.85	.278	−2.97	6.93	−.344	−.678	−7.88	−1.5
		[1.5]	[1.3]	[2.8]	[.11]	[2.3]	[.794]	[3.1]	[.587]	[1.5]
Fertilizer	−13.29	−3.32	−15.40	—	−84.09	−3.63	−18.87	−2.60	−31.65	−1.40
	[3.4]	[4.5]	[8.5]	—	[4.3]	[8.6]	[36.29]	[6.3]	[5.0]	[6.1]
Lagged price	—[b]	−.23	3.37	—	183.00	.024	5.31	.014	1.68	−.08
		[−2.1]	[−33.0]	—	[−25.53]	[7.8]	[−5.6]	[−1.4]	[16.8]	[1.9]
Net annual change (percent)	−7.81	−2.33	−29.65	.682	+157.47	+.21	−.26	−1.41	+18.48	+1.81

[a] Forecasted annual changes in the independent variables appear in brackets. Where experts disagree with these forecasts, the price changes can be easily recalculated.
[b] Negligible.
[c] GNP substituted for per capita income.

Table 5. Postmiracle-grain "free market" estimates of price changes, 1967–1975[a]

	India		Philippines		Brazil		World	
	Symmetrical	Semi-responsive	Symmetrical	Semi-responsive	Symmetrical	Semi-responsive	Symmetrical	Semi-responsive
Average annual price change percentage attributed to changes in:								
Per capita income	22.23	22.23	13.64	13.64	56.29	56.29	4.79	4.79
Area	−39.85	−78.49	−.344	−.688	−7.88	−15.76	−1.50	−3.00
Fertilizer	−18.62	−37.23	−23.71	−47.54	−39.55	−63.30	−5.31	−9.64
Lagged price	3.70	4.67	9.92	16.46	1.23	−1.59	−0.08	.107
Net annual change (percent)	−32.54	−88.82	−1.18	−18.13	+10.09	−24.36	−2.10	−7.74

[a] New marginal physical products relating fertilizer inputs to output were calculated from nonstatistical postmiracle-grain output estimates and least-squares estimates of fertilizer demand. "Symmetrical responsiveness" assumes that output response to price declines is identical to that for price rises. "Semiresponsiveness" assumes downward output stickiness and that production is only about half as responsive to price declines as to price rises.

Impact of price changes on rice output

Output changes in response to rice price changes (as percentage deviations from the constant-price forecast) can be estimated from the simultaneous price adjustments and from the input elasticities of the structural equations by multiplying estimated net annual price changes by the price elasticity of fertilizer and that by the fertilizer elasticity of output, that is, $\%\Delta\hat{Q} = \%\Delta(\hat{P}/C\hat{L}I) \cdot (F.P) \cdot (Q.F)$. Where estimated elasticities are very large, we have a special statistical problem. All of the estimated price elasticities from the original structural equations are of course increasingly inaccurate as we move from the mean values in these relations. An equilibrium shift that results in a 20 percent price decline, for example, would move the supply curve to an intersection of the demand curve that is a great distance from the estimated mean of the quantities demanded. It is virtually certain that the coefficients of elasticity at the new point on the demand curve are substantially different from these estimated values. To adjust for this, we assume that the impact of all "extreme" price changes are exhausted in a limited number of years. In terms of output changes, this turned out to be a problem only for India and South Korea.

In virtually all nations the constant-price *consumption* figures do not deviate from the consumption estimate at alternative prices. A significant price elasticity coefficient for the *nominal* world price was derived, however, and was used in estimating an adjusted world consumption total. The consequences of adjusting production and consumption estimates for price-change impact are reflected in the trade estimates at changing prices (Table 6).

World and National Production, Consumption, and Trade Estimates, 1967–1975

Total 1975 world consumption and production estimates[8] appear in Tables 7 and 8. We expect that the increased volume of rice moving in world trade (about 10 percent of total Q_r by 1975) will result in a higher average price elasticity than now prevails because rice will increasingly become a private market commodity. If world rice prices remain at their 1966 level through 1975, the total world production surplus is estimated at an annual rate of 26.56 million milled metric tons. In reality, of course,

[8] Total world and national rice production and consumption equation estimates yearly, 1967–1975, are available upon request.

Table 6. Rice trade of selected major nations at changing "free market" prices, 1975 (in millions of milled metric tons)

Nation	At premiracle-grain price changes	At postmiracle-grain price changes	
		Symmetrical	Semi-responsive
Japan	−.099[a]	—	—
United States	1.960	—	—
India	−6.560	−8.580	−3.780
Thailand	3.582	—	—
Burma	1.923	—	—
South Korea[b]	8.285	—	—
Malaysia	−.342	−.342	−.342
Philippines	.531	.331	.471
Brazil	.838	.838	.838

[a] A negative sign indicates that the nation is a net importer.
[b] There apparently are severe structural problems in South Korea unrelated to producer responsiveness that would prevent this high export figure from being attained.

the miracle grain revolution will have an impact on rice-price changes. After all producers and consumers have adjusted as expected to price changes through 1975, we expect a world surplus in rice equaling 8.74 million milled metric tons at an annual rate. The nominal world price of rice will have declined by 62 percent from its 1967 figure level by 1975.[9] The final consumption adjustment would narrow the surplus to only 2.34 million metric tons.[10] What follows is some country-by-country results.

The "most likely" national trade balance figures appear in Table 9 below, except for Indonesia, Nepal, South Vietnam, and Mainland China estimates. On the basis of FAO estimates of 1975 consumption, Indonesia is expected to import a net 2.95 million milled metric tons in 1975 at constant prices. This trade deficit would probably move close to zero if miracle grains are adopted successfully. The FAO estimate of consumption for Nepal indicates that the country will continue to run a trade surplus of an estimated 800,000 in 1975. With continued adoption of the IRRI varieties and a substantial diminution in the war by 1972, self-sufficiency by South Vietnam should be obtainable again. According to the FAO estimate of 1975 consumption, South Vietnam should be exporting an estimated 550,000 milled metric tons in 1975 at 1966 prices. Production and consumption forecasts from FAO for Mainland China include net exports of at least 650,000 milled metric tons in 1975.

The domestic farm rice price is supported by the governments of Japan, the Philippines, the United States, India, and Malaysia. The removal of such supports under the pressure of rising subsidy costs would result in the deflations estimated in Table 4. Presumably rice production in each of these nations would be lower also. In 1965 Japan's support price was more than 2.5 times the world average export price.

In all nations studied except perhaps Burma and Malaysia, most output increases are expected to come from more intensive cultivation and rising yields. In Burma and Malaysia area utilized for rice production has increased faster than in other parts of Asia. The miracle rice is expected to affect significantly production in India, Pakistan, the Philippines, and South Vietnam; for these nations we need initially

[9] To illustrate how surpluses could be influenced by the failure to take into account possible interdependencies between production and demand, we adjusted these price-influenced totals (World surplus I in Table 7) by an *arbitrary* 3 percent extra increment of consumption (World surplus II).

[10] In terms of strict statistical interpretation, these estimates are midpoints within a range of possible values.

Table 7. Total rice production at changing "free market" prices, 1975 (in millions of milled metric tons)

Nation	At 1966 prices	With non-miracle, symmetrical price changes	With miracle price changes: Symmetrical	With miracle price changes: Semi-response
Japan	14.43	12.70	—	—
United States	3.18	3.20	—	—
India	49.27	38.60	36.58	41.38
Pakistan	17.02	—	—	—
Thailand	10.97	11.16	—	—
Indonesia	9.12	—	—	—
Burma	6.41	6.42	—	—
South Korea	4.65	12.37	—	—
Nepal	2.11	—	—	—
Malaysia	1.16	—	—	—
Philippines	6.80	6.80	6.60	6.74
South Vietnam	4.78	—	—	—
Brazil	7.69	7.69	7.69	7.69
Mainland China (FAO)	72.70	—	—	—
Rest of World	13.50	—	—	—
World production totals	223.79	225.42	220.93	222.07
World consumption totals	197.23	192.07	201.60	213.23
World surplus I	26.56	33.35	19.33	8.74
World surplus II[a]	20.64	27.59	13.28	2.34

[a] This estimate is derived by increasing total consumption an arbitrary 3 percent because of supply-demand interaction.

Table 8. Total world rice demand at 1966 prices, 1975

Japan	12.80
United States	1.24
India	45.16
India (adjusted)	(47.87)
Pakistan	14.19
Thailand	7.58
Burma	4.50
South Korea	4.09
Philippines	6.27
Malaysia	1.51
Brazil	6.85
West Germany	0.24
Rest of world[a]	92.80
World total	197.23

[a] The value for "rest of world" is derived from an aggregate world equation. Of the "rest of the world," about 79 percent is attributable to Mainland China and another 14 percent to Indonesia. It was not possible to obtain accurate data for Mainland China and usable income statistics were not available for Indonesia (or Vietnam).

Table 9. Rice trade of major nations at 1966 prices, 1967–1975 (in millions of milled metric tons)

Year \ Nation	Japan	United States	India	Pakistan	Thailand	Burma	South Korea	Malaysia	Philippines	Brazil
1967	1.138	1.418	n.a. [−5.599][a]	n.a. [.337]	2.989	1.431	.270	−.239	n.a. [.598]	−.352
1968	1.192	1.483	5.187 [−5.326]	2.512 [−.738]	3.027	1.478	.251	−.252	2.252 [.207]	−.264
1969	1.246	1.549	4.555 [−3.749]	3.816 [1.032]	3.224	1.530	.353	−.266	2.361 [−.271]	−.292
1970	1.308	1.614	3.841 [−3.462]	3.774 [1.178]	3.257	1.586	.339	−.277	2.527 [−.543]	−.056
1971	1.369	1.679	4.584 [−3.180]	3.787 [1.332]	3.287	1.645	.327	−.282	2.487 [−.876]	.077
1972	1.430	1.744	4.121 [−2.903]	3.898 [1.491]	3.316	1.708	.384	−.303	2.328 [−1.285]	.231
1973	1.501	1.810	3.596 [−2.634]	4.063 [1.657]	3.344	1.774	.443	−.316	1.978 [−1.786]	.404
1974	1.571	1.875	3.564 [−2.361]	4.120 [1.830]	3.369	1.842	.503	−.329	1.320 [−2.399]	.616
1975	1.631	1.940	1.400 [−2.107]	3.826 [1.946]	3.392	1.913	.565	−.342	.531 [−3.144]	.838

[a] The trade values in brackets are based on least-squares equations estimates and hence do not include the effect of technological change. The difference in the two estimates indicate the impact of technological change (new seed varieties) on trade. A negative sign indicates that the nation is a net importer.

nonequation estimates of output.

There are only two exceptions to an estimated zero price elasticity of demand: Demand is estimated as sensitive (in the normal direction) in Malaysia; rice appears to be a Giffen-good in Burma.

Except for the above and subsequent qualifications, the reader can rely upon the tables for estimates. Contrary to the perverse response suggested by our statistically estimated output changes, a "free market" and U.S. rice price decline of 2.33 percent annually through 1975 would probably yield a somewhat lower level of production. As acreage controls and price supports have been such major factors in the American market, we have been unable to estimate accurately the responsiveness of American producers to such price declines. The responsiveness of output to both fertilizer and irrigation inputs could rise substantially in Indonesia. Because of problems including those with land tenure, production credit, effective water control, and continued expansion of cultivated land, we have discounted a similar possibility in Thailand.

Although statistically South Korean production *appears* to be highly sensitive to input changes, there seem to be substantial production-inhibiting forces in that country. The main constraint appears to be limited land availability, as we forecast a total increase in land utilized of less than 1/2 of 1 percent between 1970 and 1975. The apparent *lack* of statistical responsiveness of production to price changes in Malaysia is probably due to the fact that we were able to use only the export price in our equations for Malaysia rather than a domestic price. Elimination of the subsidy program there would result in an estimated annual decline in the real price of rice of 1.41 percent per year through 1975; *irrespective of our statistical results on responsiveness*, such price declines probably would reduce production.

Summary and Conclusions

In evaluating estimates of rice production, consumption, trade, and price changes, one should remember that the world has in the past decade produced enough rice to meet world demand. Starvation and low nutrition levels of people in less developed nations has resulted not from an inadequacy of world output capacity, but rather from unequal distribution of food output. If the green revolution is viewed with that perspective, it is clear that its first goal is the feeding of indigenous populations.

Traditionally the major Far East exporters of rice have been Burma, Cambodia, Taiwan, Thailand, and Vietnam. Other traditional ex-

porters include the United States, Mainland China, the United Arab Republic, and Brazil. The traditional Far East importers have included Japan, Ceylon, India, Indonesia, Malaysia, Pakistan, the Philippines, and South Korea. At constant prices many of these traditional Far East importers—India, Pakistan, the Philippines, and South Korea—are expected to be net exporters themselves during the 1970's. Only India and Pakistan would be exceptions to this shift if the domestic producer price of rice in these countries is allowed to decline sharply.

Moreover, Indonesia and Malaysia are attempting to move to a surplus position or at least reduce their imports and may adopt the miracle grains. The Soviet Union, recently a modest importer, has been aiming at self-sufficiency. If *current government policies* continue, the Japanese and American rice surpluses are expected to grow substantially through the 1970's. Although Thailand's trade surplus is expected to grow slowly, we expect substantial increases in the size of Burma's surplus. South Vietnam is expected to return to her traditional role as a rice exporter in 1972. The most conservative projection of the change in trading relations indicates that the green revolution will turn traditional trading patterns virtually upside down.

Several policy implications emerge from these expected new trade patterns. The United States Government may want to plan early a severe acreage restriction program. But even if the United States and Japan were to shift to subsistence rice production, there would still be a substantial world surplus of rice at constant prices (and hence downward price pressure) in 1975.

The main problems between today and 1975 probably relate to income distribution and levels. Because the new varieties of food crops require substantial supplies of fertilizers with irrigation and modern cultivation methods, this agricultural technology has largely benefited the larger, more wealthy farmers. There is a possibility that small farmers may gradually be pushed out of the market by the large producers, and tenant farmers may be evicted in certain nations. The sharecropping peasants live at or below subsistence level, owning only a few crude farm tools; the benefits of the green revolution may never reach them.

A second income problem is one of income maintenance in a world of declining rice prices. The governments in the LDC's will have to decide whether to control production increases (by acreage, storage, or both) or to subsidize rice production at increasingly higher levels. *The problem of declining prices is related to the problem of income distribution.* When rice prices fall they will reach that point at which production of local varieties will be unprofitable much sooner than they reach a point at which production of the miracle grain rice is unprofitable. Presumably, then, it will be the smaller farmers who will be most adversely affected by falling rice prices. The precise marginal income distribution from the revolution will of course vary by nation. Income levels in the traditional exporting LDC's also will be adversely affected prior to the new miracle grain users; these nations would include Burma, Thailand, and Indonesia.

Unless substantial governmental policy changes are implemented by both the developed and the developing nations, there will be a new major source of conflict between the rich and poor countries. LDC trade gains from this production breakthrough will not be forthcoming without the cooperation of the developed nations and rational production controls by the LDC's. The foremost advantages of the agricultural revolution are the possibilities of eliminating hunger and starvation while reducing LDC import needs and perhaps generating an environment in which population growth will be slowed. To achieve these gains, however, requires a relatively even distribution of marginal income. Unless the peasant populations are induced to participate in the miracle grain revolution, widening disparities in income distribution may still leave large numbers deprived of food supplies. Then the maldistribution of grains that was once global will be national as well.

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Discussion: VERNON W. RUTTAN, *University of Minnesota*

I like the paper by I. J. Singh. I admire the skill with which he has successfully integrated recent extensions of the neoclassical theory of the firm (a) to incorporate the production, consumption, and investment behavior of the household-firm; and (b) in econometric method, recursive linear programming, and activity analysis to simulate the behavior of the agricultural sector of the Punjab during a period when the region was undergoing rapid change in agricultural technology and rapid transition from subsistence to commercial agricultural production. Singh has neglected, however, to tell us how closely his model projections synthesize actual behavior during the 1952–1968 period. I would like to see the results of model predictions based on alternative factor-factor and factor-product prices ratios. I would also like to see the implications of alternative and institutional arrangements in the labor, capital, and land markets explored more thoroughly.

I also like the paper by Howard Barnum. The paper skillfully analyzes (a) the impact of PL 480 grain shipments on total foodgrain production, commercial imports, and consumption and (b) the effects of a program of managing feedgrain stocks to reduce dependence of imports on total production, imports, and consumption. The first part of the paper is less impressive than the second part. The evaluation of the effect of introducing stochastic terms into the simulation seems to me rather trivial. I am troubled by his failure to relate his results to those of previous investigations, particularly the work of J. S. Mann. The stock management analysis is, in my judgment the most significant aspect of the paper. It is a real advance over the Raj Krishna paper.

My reactions to the paper by Canterbery and Bickel are somewhat different. I like the topic; I like the conclusions; but I don't care for the analysis. I find my esthetic sensibilities offended by the "adhockery" of their methodology.

My skepticism is greatest with respect to the production relations. The authors indicate that area, fertilizer consumption, and prices "explain" most of the changes in output of grains in 1955–1966. The authors seem unaware of the very substantial supply response literature for rice (by Behrman, Hussain, Krishna, Mubyarto, Managahas, and others). A review of the individual country studies indicates that a need for considerably greater precision in the specification of the variables that influence output or the two major components into which output can be partitioned (area planted and yield). The area planted to rice, in particular, is quite responsive in many areas to the prices of the individual commodities that directly compete with rice for area.

Let me summarize. I remain highly skeptical of the model employed by Canterbery and Bickel and of the estimated relationships presented. The authors simply do not know enough about the world rice economy to be playing the world rice market outlook game.

Discussion: LOUIS M. GOREUX, *World Bank*

I shall restrict my comments to the papers presented by Singh and Barnum.

Singh's study appears very promising and I would be interested to see further research in two directions. The first relates to farmers' behavior; the second to the link between the area studied and the rest of the economy.

(1) Professor Singh stresses that his pro-

gramming model simulates closely the process of agricultural development in the area. This claim should be supported by a careful analysis of the discrepancy between the actual data and those generated by the model between 1952 and 1965. The sensitivity of these discrepancies to the choice of the behavioral constraints should be studied. Thus the importance of the flexibility and adoption constraints could be assessed.

(2) Maximizing the farmer's objective function, subject to behavioral constraints, may not lead to maximum social welfare for the country as a whole. For resources transferable between the area and the rest of the economy (such as tractors, fuel, capital, and labor), the opportunity cost to the country may differ from the market price paid by the farmer. Short of building an optimizing model for the economy as a whole, experimentation with parametric variations of the shadow prices of the central resources could be conducted. Thus, investments in the area could be larger (or smaller) than the savings made in this area, depending on whether the opportunity cost of capital is higher (or smaller) in this area than in the rest of the economy.

In his paper Barnum finds, as Mann [1] did, that PL 480 induced a decline in grain prices to domestic producers and, consequently, in domestic grain production. I agree with this finding. However, I question the validity of some of the estimates.

The model has been estimated from historical data with PL 480. To use the same model for assessing what would have occurred without PL 480 one needs to be sure that suppressing PL 480 imports would not have affected some of the variables taken as exogenous.

(1) If the government had followed a sensible storage policy, the value of the yearly changes in government stocks should have been different without PL 480 imports. This is not taken into account.

(2) The suppression of PL 480 would presumably have reduced the capacity to import goods other than grains and consequently the value added by the nongrain sectors. Because this effect is not taken into account, suppressing PL 480 by raising domestic grain production automatically raises national product.

(3) If grain prices are positively correlated with the price of substitutes, reducing consumption should raise the price of the substitutes, provided that the supply elasticity of these substitutes is less than infinitely price elastic. Since the price of substitutes is assumed to remain the same with and without PL 480, reducing grain consumption by 10 percent induces only a 12 percent increase in the price of grains, which implies a price elasticity of $-.85$. The price elasticity of $-.34$ found by Mann and the NCAER seems much more reasonable.

(4) My main objection is to assume that with and without PL 480 the volume of commercial imports would remain a constant proportion (.1287) of grain availabilities before commercial imports (equation 3). PL 480 imports has accounted in some years for a large proportion of grain supplies in cities such as Bombay and Calcutta. Having suppressed PL 480 imports and increased commercial imports by only 13 percent of the PL 480 imports foregone would have caused a drastic reduction of grain supply in these cities. The true dollar cost of PL 480 imports was more than 15 percent of the cost of commercial imports. Why should the government have saved on the dollar cost of all grain imports if PL 480 had been suppressed? Experience in Mainland China suggests that to face a severe grain shortage in cities governments are ready even to reduce the import of capital goods.

I believe that improving the specifications of the model would probably be more important than introducing stochastic elements. We need to recall that we have a model only for the grain sector and that it is difficult to reconstruct what would have occurred in the absence of PL 480 without considering the trade-offs between the grain sector and the rest of the economy.

To conclude, I wish to stress that the production function estimated by Barnum is a very substantial improvement over the one estimated previously by Mann, especially regarding its dynamics properties.

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Discussion: JOHN W. MELLOR, *Cornell University*

Until recently backwardness in agriculture was viewed largely as a product of cultural patterns inappropriate to quantitative economic analysis. Unfortunately, our conceptualization continues to suffer from failure to recognize the substantial extent to which common rules of thumb and observed relationships are the products of their environment and therefore potentially misleading in the different economic environment of early stage development [3, 5]. Weakness in conceptualization not only leads to erroneous intuition concerning policy but to erroneous specification of models and weak ability to note inconsistency and error in results. Models continue to suffer from paucity of analysis concerning assumed exogenously determined variables. More basically, a high proportion of current work assumes continuation of structural relationships which are themselves the antithesis of development.

Particularly useful in Singh's analysis is the effect of technological change on volume of marketings, a subject bound to revive in importance as the employment implications of the green revolution become more clearly related to transfer of agricultural commodities to the urban labor force [5]. The model poses a number of difficulties. Markets for labor, capital, and even land work surprisingly well in most low income countries; hence the rigid resource restraints so common in linear programming models are inappropriate [3]. Singh has been ingenious and successful in his specification of restraints. However, the flexibility restraints, such as rate of adoption of technology, are important to answering questions of timing but are so poorly understood that they remain important subjects of further research.

Barnum tackles smaller questions and is able to use more fully substantiated assumptions. Simulation of the market for foodgrains in India concludes that a decrease in domestic foodgrains production incident to PL 480 has been small. This is consistent with an earlier simulation of price effects [4]. The model illustrates dangers of use of past relationships to prescribe future policy. In India PL 480 foodgrains probably have not been used to expand employment. If they were, average demand elasticities would be reduced, prices would fall less or rise more than indicated, and the reduction in domestic production would be less than indicated. Simulation can be used to test the effect of such structural changes.

The Canterbery-Bickel paper illustrates the extreme problem of dealing with complex processes with current quantitative tools and data. Such a large number of arbitrary assumptions must be made that we are probably better off at the mercy of intuitive insights of experienced policy practitioners. Estimation of effects of a major new technology on trade patterns requires estimates of the production effects of the new technology where it is applied, the rate and extent of application, and the effect of the new technologies on income distribution and hence on the structure of demand. This latter problem is important, generally neglected, and probably causes substantial underestimation of the demand elasticities.

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POSITION AND PROSPECTS OF BLACKS IN THE NATIONAL ECONOMY

(Joint Session, AAEA and AEA)

CHAIRMAN: JAMES G. MADDOX, North Carolina State University

Prospects for Black Farmers in the Years Ahead

HENRY PONDER

BLACK RURAL population is about three-tenths of the total black population. Most blacks and other minority groups, except the American Indians, live in urban areas. Between 1960 and 1968, about 28 percent of the drop in farm population was the result of the exodus of blacks and other minority groups [3, p. 58]. Many of the problems that beset blacks everywhere occur in their most severe, undiluted, and least hopeful settings in the countryside; and to the extent that rural areas continue to be a seedbed for the cities, the problems of the rural minority continue to be the problems of all [1, p. 161].

In 1964 there were 199,952 nonwhite farm operators in the United States [4, p. 760]. Of this total 92 percent were blacks and 8 percent were classified as other nonwhite. Ninety-two percent of all nonwhite operators were in the South, and of these 98 percent were black.

For this analysis black is used synonymously with Negro and nonwhite. The census data for nonwhites are treated as all black, since 92 percent and 98 percent for the United States and the South, respectively, are black. Even with this overstatement of the data for blacks, the conclusions should be valid.

Number of Farm Operators

The peak year for black farm operators was 1920, when they numbered 925,710 (Table 1). This was 14.34 percent of the total farm operators in the United States in 1920 (Table 1). In 1964 the number of black operators had decreased 80.1 percent from 1920. In 1964 one in each 19 farmers was black, compared to 1920 when one in seven U. S. farmers was black.

Since 1900 the South has been home for more more than 98 percent of all U. S. black farm operators, while the North had somewhat more than one percent and the West never reached one percent (Table 1). This distribution has great significance when one considers the history of race relations in this country.

The states with more than 10,000 black farm operators in 1964 were Tennessee (10,624); Georgia (11,233); Texas (11,489); Virginia (11,583); Louisiana (12,272); South Carolina (19,582); Alabama (20,936); North Carolina (27,442); and Mississippi (37,543).

Outside the South the states with the largest number of black farm operators were Ohio (496); Michigan (488); California (337); and Illinois (277). The number of black farm operators has been decreasing since 1900.

Tenure and Acreage

The black colleges and extension workers did a fairly decent job of instilling in black farmers pride of ownership. Since 1930 there has been a steady increase in the percentage of owners among black operators (Table 2). In 1964, 39.3 percent of all black farm operators were owners (Table 2).

The percent of part owners has also been increasing—from 4.8 percent of all black operators in 1930 to 17.4 percent in 1964 (Table 2). Part ownership gives the operator more flexibility in using his capital.

The number of acres operated by black part owners exceeded that of black full owners in 1964 (Table 3).

In 1964 black full and part owners made up more than 56 percent of all black farm operators. These two tenure classes farmed more than 10.2 million acres.

Blacks have not been involved in large numbers as farm managers. This is due to many things, but education is of prime importance. More than 80 percent of all black farm operators had eight years of education or less in 1964 (Table 4).

In 1964 the number of black tenants dropped below the combined total of owners, part owners, and managers for the first time (Table 2). The number of acres operated by black tenants

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Table 1. Number of Negro farm operators, by United States and regions, 1900 to 1964

United States and region	1964	1959	1954	1950	1940	1930	1920	1910	1900
				Number of operators					
United States	184,004	272,541	*	559,980	681,790	882,852	925,710		746,716
North	3,032	4,855	6,946	7,702	8,898	11,104	9,380	12,052	14,016
South	180,418	267,008	459,907	551,469	672,214	870,936	915,595	880,836	732,362
West	554	678		809	678	812	735		339
				Percent distribution					
United States	100.0	100.0		100.0	100.0	100.0	100.0		100.0
North	1.65	1.78		1.38	1.31	1.26	1.01		1.87
South	98.05	97.97		98.48	98.59	98.65	98.91		98.08
West	0.30	0.25		0.14	0.10	0.09	0.08		0.05
				Percent of the total farm operators					
United States	5.83	7.35		10.39	11.17	14.03	14.34		13.00
North	0.21	0.28	0.34	0.34	0.35	0.43	0.34	0.42	0.49
South	13.14	16.22	19.85	20.79	22.35	27.02	28.55	28.44	27.95
West	0.18	0.19		0.17	0.13	0.16	0.15		0.14

* Blanks indicate data are not available.

Table 2. All farm operators and number of nonwhite farms, and tenure of operator, United States, 1920 to 1964

Color and tenure of operator	1964	1959	1954	1950	1940	1930	1920
				Number of farms			
All farm operators	3,157,857	3,707,973	4,783,021	5,388,437	6,102,417	6,295,103	6,453,991
Nonwhite total	199,952	284,612	481,601	585,917	723,504	921,400	954,284
Full owners	78,533	97,388	139,978	154,706	168,236	159,894	193,126
Part owners	34,833	40,733	54,068	55,919	33,824	43,863	40,888
Managers	396	489	658	506	751	3,202	2,258
All tenants	86,190	141,017	286,798	374,786	520,693	714,433	718,009
				Percent distribution, by tenure			
All farm operators	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Nonwhite total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Full owners	39.3	34.8	29.1	26.4	23.3	17.4	20.2
Part owners	17.4	14.6	11.2	9.5	4.7	4.8	4.3
Managers	0.2	0.2	0.1	0.1	0.1	0.3	0.2
All tenants	43.1	50.4	59.6	64.0	72.0	77.5	75.2

Table 3. All land in farms and nonwhite operators, by tenure of operator, United States, 1920 to 1964

Color and tenure of operator	All land in farms (acres)						
	1964	1959	1954	1950	1940	1930	1920
Nonwhite total	46,835,999	53,142,456	58,050,255	63,268,795	46,012,579	41,347,051	44,944,684
Full owners	5,119,722	6,584,532	8,171,664	9,549,326	21,383,893	10,713,405	14,005,208
Part owners	5,155,353	5,332,690	5,945,955	5,912,854	3,142,635	3,137,341	2,698,984
Managers	32,571,416	35,421,952	33,984,785	32,818,071	343,542	548,609	475,679
All tenants	3,989,508	5,542,676	9,947,851	14,366,739	21,142,509	26,923,920	27,764,650
				Average acreage per farm			
All farm operators	351.6	303.0	242.5	215.5	174.5	157.3	*
Nonwhite total	234.2	186.7	120.5	108.0	63.6	44.9	
Full owners	65.2	67.6	58.4	62.2	127.1	67.0	
Part owners	148.0	130.6	110.0	106.8	92.9	71.5	
Managers	82,251.1	72,437.5	51,648.6	69,677.4	457.4	171.3	
All tenants	46.3	39.3	34.7	38.7	40.6	37.7	

* Blanks indicate data are not available.

Table 4. Highest grade of school completed and percent of farms operated by nonwhite operators, the South, 1964

Highest grade of school completed by farm operators	Total number of farms	Percent of all farms
Elementary:		
0 to 4 years	67,779	36.72
5 to 7 years	62,707	33.97
8 years	20,158	10.92
High school:		
1 to 3 years	20,065	10.87
4 years	7,333	3.97
College:		
1 to 3 years	2,079	1.13
4 years or more	2,609	1.41
Total number of farms	184,578	100.00

has been constantly decreasing since 1920, from over 27.7 million acres in 1920 to just under 4.0 million acres in 1964 (Table 3).

Farms Operated by Nonwhite Operators in the South

The 1964 U.S. Census of Agriculture reports characteristics of farms operated by nonwhite operators for the South only. These statistics should be reliable, since the South had 92 percent of all nonwhite farm operators and of these 98 percent were blacks.

Value of farm

More than 69 percent of the farms operated by nonwhites in the South were valued at less than $10,000 in 1964 (Table 5). Nonwhite operators had 41 farms valued at $500,000 or more in 1964.

Size of farm

The average acres per farm operated by nonwhites was just under 45 acres in 1920 and just over 56 acres in 1964 (Table 5). The land in farms was just over 10.4 million acres in 1964 (Table 5).

More than 66 percent of all farms operated by nonwhite operators in the South were less than 50 acres in size in 1964; and fewer than one percent were 500 acres or more in size (Table 6).

Farms smaller than 50 acres operated by nonwhite operators accounted for 42 percent of the cropland harvested on all farms of nonwhite operators, but they accounted for 64 percent of the tobacco acreage harvested and 54 percent of the cotton acreage harvested on all farms operated by nonwhite operators [4, p. 762].

Table 5. Farms, acreage, and value of farms operated by nonwhite operators and percent of total for the South, 1964

Acreage and value of farms	Total number of farms	Percent of all farms
Number of farms	184,578	100.0
Land in farms (acres)	10,439,934	100.0
Average size of farms (acres)	56.6	
Value of land and buildings		
Average per farm (dollars)	10,064	
Average per acre (dollars)	176.48	
Value of farms (dollars)		
Less than 10,000	128,029	69.36
10,000 to 19,999	31,476	17.05
20,000 to 39,999	16,324	8.84
40,000 to 69,999	4,825	2.61
70,000 to 99,999	1,192	0.65
100,000 to 149,999	471	0.26
150,000 to 199,999	189	0.10
200,000 to 499,999	183	0.10
500,000 or more	41	0.02

Economic class of farm

The Bureau of the census defines commercial farms as farms with a value of farm products sold of $2,500 or more and those with less than $2,500 in sales provided that the operator was under 65 years of age and worked fewer than 100 days off his farm during the year.

Almost 64 percent of all farms operated by nonwhite operators in the South were classified as commercial in 1964. Approximately 70 percent of the farms of less than 50 acres operated

Table 6. Farms by size of farms operated by nonwhite operators and percent of total for the South, 1964

Size of farms (acres)	Total number of farms	Percent of all farms
Total number of farms	184,578	100.0
Less than 10 acres	25,613	13.88
10 to 49	97,681	52.92
50 to 69	17,308	9.38
70 to 99	16,769	9.09
100 to 139	11,529	6.25
140 to 179	6,257	3.39
180 to 219	3,244	1.76
220 to 259	1,863	1.01
260 to 499	3,274	1.77
500 to 699	548	0.30
700 to 999	272	0.15
1,000 to 1,999	163	0.09
2,000 or more	57	0.03

Table 7. Amount of income of all household members and percent of total farms operated by nonwhite operators, the South, 1964

Income of households	Total number of farms	Percent of all farms
$1 to $499	35,388	19.17
$500 to $999	30,335	16.44
$1,000 to $1,499	18,606	10.08
$1,500 to $1,999	12,175	6.60
$2,000 to $2,999	15,760	8.54
$3,000 to $3,999	10,265	5.56
$4,000 to $4,999	5,919	3.21
$5,000 and over	9,039	4.90
Income of households from other sources greater than value of farm products sold	69,857	37.85
Total number of farms	184,578	100.00

by nonwhites sold less than $2,500 of farm products in 1964. Farms less than 50 acres in size accounted for 53 percent of the total value of farm products sold from farms operated by nonwhite operators [4, p. 762].

The Department of Agriculture figures as a rule of thumb that a farmer must sell at least $10,000 worth of products annually if he expects to make a minimum net income of $2,500 and that he needs $2,500 of net income to maintain a minimum decent level of living [1, p. 179]. In 1964, 75 percent of nonwhite operators of commercial farms sold less than $5,000 of farm products.

The average value per farm of all products sold was $2,705 for farms operated by nonwhite operators in the South in 1964. Slightly less than 40 percent of all nonwhite farm operators in the South reported income they and members of their households received from other sources to be greater than the value of farm products sold in 1964 (Table 7). Just under 20 percent of these had other incomes of less than $500.

Type of farming

In 1964 cotton and tobacco farms made up over 75 percent of all the commercial farms operated by nonwhite operators in the South (Table 8). These crops are labor intensive and make use of the operator's family labor. For the same period and group, 62 percent of the farm acreage was devoted to these crops.

Approximately 55 percent of the tobacco farms and 86 percent of the cotton farms had less than $5,000 of farm products sold in 1964.

Conclusions

It is a fact in history that blacks were imported to this country to help the agricultural economy of the South. The South is where slaves landed, and for the masses it is where they stayed. It is not surprising that in 1964 98 percent of all black farm operators were in the South. Whatever the black farmers' future, it is tied closely to the South.

Farming is a declining industry, and the number of black farm operators has shown a steady decline since 1920. The exodus of black farm operators is expected to continue to decrease in the future, but at a decreasing rate.

The decrease in black farm operators is reflected by decreases in all the tenant classes. A

Table 8. Characteristics of commercial farms operated by nonwhite operators, by type and percent of total for the South, 1964

Average size and value of farms	Total commercial farms	Tobacco	Cotton	Poultry	Dairy	Livestock farms except poultry and dairy	General
Farms—number	117,090	31,421	58,176	455	1,154	4,713	8,397
Percent	100.0[a]	26.6	49.3	0.4	1.0	4.0	7.1
Land in farms							
Acres	7,130,704	1,412,973	3,010,387	28,726	150,741	680,741	878,618
Percent	100.0[a]	19.8	42.2	0.4	2.1	9.5	2.3
Average size of farm (acres)	60.5	45.0	51.7	63.1	130.6	144.4	104.6
Value of land and buildings:							
Average per farm-dollars	11,553	13,745	8,524	18,581	21,642	17,527	16,582
Average per acre-dollars	189.31	305.14	162.72	245.26	168.91	121.65	160.18

[a] Percentage does not add up to 100 because the following type farms are missing: cash-grain, other field-crops, vegetables, fruit and nuts, and miscellaneous.

good sign is that the percentage of owners and part owners is increasing for black farm operators and the percentage of tenants is decreasing.

The trend toward ownership of land has increased, while the number of acres owned by black farm operators has been decreasing. In the 10-year period 1954–1964 black land ownership decreased from 14.1 million acres to 10.2 million acres. The average acreage per farm for black owners was 65.2 acres in 1964.

Land ownership is of prime consideration to remaining in farming, because the tenant must give up his land when the owner wishes it. With mechanization increasing, more owners will be farming more land. This will cause a further decrease in the number of black farm operators.

Black operators had only an average of $176.48 invested per acre in 1964. More than two-thirds operated farms valued at $70,000 or less in 1964. Almost 70 percent farmed less than 50 acres. This is an indication of why three-fourths of these farms sold farm products worth less than $5,000. Since $10,000 in farm product sales is considered adequate, an overwhelmingly large number of black operators are in the poverty class.

Lack of education, along with other factors, indicates that the future role of the black operator will be that of a tenant or hired hand, if he remains in farming.

Three-fourths of commercial farms operated by black farmers were cotton and tobacco farms. Most cotton is farmed mechanically, and blacks have small farms that make this unprofitable.

Tobacco is labor intensive and is more suited to the small farms operated by blacks. The future will see more mechanization of tobacco farming, which will place the black operator at a disadvantage.

The above seems to indicate a dismal future for black farmers. When we add to the picture the culture and tradition of the rural South, the black farmer's future is dismal indeed.

If the black farmer needs credit to purchase a farm, he usually finds the lending agencies unresponsive to his requests. Even the federal lending agencies are generally not receptive to his request for a loan. This lack of receptiveness on the part of lending agencies is helping to decrease the number of black farm operators.

Black farmers have discovered that it is very difficult to become members of the various county and community agricultural committees. The Department of Agriculture's Agricultural Stabilization and Conservation Service plays a major role in the South's farm economy. ASCS county and community committees allot the acreages under the farm program for cotton, tobacco, and peanuts, the crops that occupy over 75 percent of black farmers. Yet in 1964 not one black was on a state ASCS committee and only a few were on the elected committees [5, p. 8]. This nonrepresentation is serving the purpose of driving blacks out of farming.

The same criticism may be made of the Extension Service. There are very few black Extension agents in the United States, but many do serve as assistants. Historically, Extension is the USDA education arm; it also represents a close alliance between the Department and the segregationist establishment in the South [2, p. 16]. Black Extension agents are needed to help black farmers secure loans and improve their farming methods.

The lure of improved civil rights in other sections of the United States has caused a large number of blacks to leave the farms of the South. This exodus cannot be stopped unless the treatment of blacks is improved.

The above indicates that the migration of black farmers to the urban centers wlll increase in the years ahead. The rate of migration may decrease, but the trend will remain. This trend will continue unless a concerted effort is made to stop it.

The problems of the black farm operator are grave. They merit the attention of the federal, state, and local governments as well as local citizens. Studies should be undertaken to determine what steps can and should be taken to keep black farm operators "down on the farm."

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Rural-Urban Migration of Blacks: Past and Future*

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AFTER THE 1920 population census Congress failed for the only time in its history to reapportion the seats of the House of Representatives. When the census results were in, it was found that for the first time urban population exceeded rural in the United States. Representatives from rural states that stood to lose a seat in reapportionment argued either for an increase in the size of the House to protect their absolute representation or favored no reapportionment at all. The affected states were in the Midwest, New England, and the South. Thus the issue was by no means a narrowly sectional one. But one major contributing factor was the migration of rural southern Negroes to northern industrial states, which the southern congressmen insisted was only temporary.

"For the last two years," said Representative Johnson of Mississippi, "there have been special trains carrying thousands of Negroes and a great many white people to the northern cities, and since this financial condition has come about in the country [i.e., the postwar economic recession] hundreds and thousands of these same people are trying to return to the South" [2, p. 1633]. "Thousands of (Mississippi's) citizens were temporarily employed in other sections of the country and they were not enumerated. Thousands of her citizens, mostly colored, were temporarily removed to Chicago and other places before the recent election, to be used politically. They have been used and are now returning to their homes, poorer but wiser" [2, p. 1645]. Representative Bee of Texas gave the ultimate assurance to the House: "Just as certain as God reigns [the men who have gone to the cities] must go back to the farms" [2, p. 1633]. Rural partisans at times frankly admitted their objection to a reapportionment that would "take away the strength and the power and the control of the Government from the rural districts and center it in the congested districts" [2, p. 1634].

In the end Congress was not able to agree on any new plan, and the 1910 census continued to be used for apportionment until the election of 1932 [4, pp. 120–122]. I recount this now nearly forgotten incident in our history to remind us that rural-urban migration of blacks (or whites) is not just a recent phenomenon or one that has only in our day affected public policy. Needless to say, comparatively few of the World War I migrants ever returned to the farm for very long. Nor did the outmovement cease with the end of the war. All but one of the states that would have lost House seats in a 1920 reapportionment proceeded to lose when the 1930 census was taken.

Although the farm population began to decline during World War I, the total white rural population continued to increase until 1940 as gains in the nonagricultural rural sectors more than offset losses from farms. The Negro rural population, however, was more highly concentrated in agriculture and 97 percent of it was in the South. When the black migration away from southern farms began, as a result of the new opportunities in the industrial North, the ravages of the cotton boll weevil, and the inability of eroded areas in the older plantation belt to produce cotton profitably, a decline in the total rural black population took place that has never been reversed. This population fell in fairly similar decade amounts from 7.1 million in 1910 to 6.6 million in 1940. There are no data on the actual number of black rural-urban migrants, but a defensible estimate would be a net of about 2.5 million during this 30-year period. The decline would have been heavier had not the rise in the popularity of cigarettes brought in tobacco as an alternative to cotton for many Negro farmers in the South Atlantic states and had not the Great Depression retarded rural-urban movement in general.

With the coming of World War II, the pace of migration to the cities changed drastically for whites and blacks alike. Burgeoning defense industries provided unprecedented job opportunities; compulsory military service took many of the young men away; and in the Delta the first large-scale displacements of tenant farmers through mechanization occurred. There was a

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brief period of return movement to farms in 1945–1946 after the end of the war. However, this was just a momentary interruption in a sustained flow of people to the cities that has persisted to the present.

The majority of black farmers were cotton tenants. As the market for cotton fell and harvest mechanization came in, they were in a particularly vulnerable position. Those who were tenants had no control over their own future in farming, and mechanization—soon augmented by chemical weed control—eliminated about 10 tenants for every 3 regular hired hands that it added. Black farm owners typically had farms that were far too small to yield a minimally adequate income (84 percent of them grossed less than $2,500 in 1959). Their average age was high, for nearly all of their grown children had left, wanting nothing to do with the occupation that they associated with the poverty of their parents.[1]

In 1950 only one percent of the cotton grown in the South (excluding Texas and Oklahoma) was machine harvested. By 1959 the figure was 25 percent; by 1969, 94 percent. The need for cotton hand labor has almost vanished. Simultaneously, acreage cutbacks and labor-saving devices have reduced the number of black tenants in tobacco farming, and peanut production—the third most important type of farming for blacks—has been mechanized.

In sum, the last 20 years have seen the departure through displacement, voluntary withdrawal, or old age of the great majority of black farm operators. There were 560,000 of them in 1950. Today unpublished surveys by the Economic Research Service indicate that no more than 100,000 are left.

The principal role of Negroes in American agriculture has changed to that of hired farm worker. More than a half million blacks still do some hired farm work, and they perform about a fifth of all man-days of farm wage work done in this country. But a majority of these workers no longer live on farms.

From 1940 to 1960, I estimate net rural-to-urban migration of blacks was about 3 million. This left a rural black population of 5.1 million in 1960, compared with the 1910 maximum of 7.1 million. However, it is essential to note that all of the net rural decline was from the farm population. The rural-nonfarm black population increased in every decade from 1920 (when the farm-nonfarm identification was first made) to 1960, rising from 1.8 million to 2.7 million. In 1960 rural-nonfarm blacks exceeded those on farms for the first time. The steady growth of the nonfarm rural population suggests that in the future the overall rural black decline may end as further losses from the now much-depleted farm sector become too small to offset nonfarm growth.

Data from the 1970 census of population are not yet available by race and residence. We know, however, from our cooperative annual surveys with the Bureau of the Census that the decline in the Negro farm population has continued to be precipitous since 1960. This population has been reduced by more than half in just 10 years, and today numbers less than one million. It would be impossible for future outmigration of blacks from farms to be as large in the next decade as in that just past, for there would be none remaining in another six or seven years if the recent absolute losses were maintained. The recent loss from farms has been so large that I doubt that rural-nonfarm gains have yet fully offset it. Census returns from the 158 nonmetropolitan counties in the nation in which Negroes comprised a majority of the rural population in 1960 show a mean decline of 6 percent in the total population of these counties from 1960 to 1970.

What of the characteristics of the migrants who left the rural areas? The proportion of rural blacks who have gone to urban areas in the last generation is so high that it includes large numbers of all segments of the population. Based on our cooperative research with James Tarver for the 1950–1960 period, I estimate that the 25–29 year-old cohort of Negroes living in rural counties in 1960 represented little more than a third of the original group of that age who were born in those counties. It is the population remaining behind in the rural environment that is more likely to be of selective composition than that which has left.

Recently new information has become available on the cumulative extent of rural-urban migration and on characteristics of the migrants. This is the data file from the Survey of Economic Opportunity, collected for the Office of Economic Opportunity by the Bureau of the Census in February 1967. In this 30,000 household national sample, data were obtained on the previous residence history of the population and related to current residence and character-

[1] For a general discussion of the characteristics of Negro farmers and factors affecting their numbers, see [1].

Table 1. Selected characteristics of the adult Negro population, by migration status, February 1967[a]

Characteristic	Rural population of rural origin	Rural-urban migrants[b]	Urban population of urban origin
Population, 17 years plus (thousand)	2,389	2,056	7,040
Families (thousand)	836	874	2,649
Unrelated individuals (thousand)	194	329	863
High school graduates (percent)	15.9	25.9	38.7
Median years of school completed	8.0	8.8	10.9
Children ever born per 1,000 women, 35–44 years old	4,937	3,360	3,470
Median family income, 1966	$2,778	$5,116	$5,105
Population in poverty (percent)	57.7	26.6	26.9
Families receiving any public assistance income, 1966 (percent)	19.9	17.3	15.6

[a] Population 17 years old and over, by 1967 residence and residence at age 16 or earlier.
[b] Migrants are persons who have ever lived more than 50 miles from their 1967 address.
Source: 1967 Survey of Economic Opportunity.

istics.[3] Migration was defined as a move of at least 50 miles distance. Tabulations compare current residence with that at age 16. Using this definition of migration, which I regard as reasonably conservative, there were 9,096,000 urban blacks 17 years old and over in 1967, of whom 2,056,000, or 22.6 percent, were of rural migrant origin. This number of rural-urban migrants is much smaller than the sum of the decade numbers cited earlier, but it must be remembered that it relates only to persons still living, excludes children under 17, and treats as nonmigrants persons whose rural-urban move was less than 50 miles.

Of the rural-urban black migrants, three-fourths were living in the central cities of metropolitan areas. Only 12 percent had gone to nonmetropolitan urban places, compared with 25 percent of white rural-urban migrants.

Among urban blacks 50 years old and over, a third were of rural migrant origin. This proportion dropped to 14 percent at ages 17–29, where much of the potential movement had yet to take place. But in view of the large number of urban-born blacks at this age group, it is unlikely that the percentage of rural migrant people will ever be as large in this cohort in the future as it is among persons presently of middle or older age.

Fully half of the black rural-urban migration has involved an interregional move from the South to the North or West. In this characteristic the black rural-urban migrants were far different from the white migrants, only one-tenth of whom had moved interregionally from the South to the rest of the country.

Educationally the rural-urban black migrants were intermediate between city natives and rural residents; 26 percent of them were high school graduates, compared with 16 percent of the rural residents and 39 percent of the urban natives. Some of their educational disadvantage was the product of the older average age of the migrants. When the population was grouped into three age ranges—17–29; 30–49; 50 and over—the differential between rural-urban migrants and urban natives was found only above age 30. At ages 17–29 the median attainment of the two groups and the proportion completing high school were essentially identical. But this means that the differential between the rural-urban migrants and rural nonmigrants has widened. In past years so few rural Negroes had obtained high school training that there was no possibility for extensive outmigration without drawing heavily from the poorly educated. In more recent years improvements in rural education have produced more differentiation in that population in level of schooling, and the selectivity of outmigration by education seems to have increased. Among blacks of rural origin 17–29 years old in 1967, about one-half of those who were high school graduates had moved to cities, whereas only one-sixth of those who had 8 years or less of schooling had done so. In all age groups the higher the amount of schooling, the higher the proportion who had moved to the city. To a partial but unknown extent some of the higher education of the migrants results from education obtained after their move to the city. The intermediate level of education of rural-urban black migrants has served to lower the average level of education in both the black population of origin and the area of destination.

In economic activity black rural-urban migrant men compared as follows with their urban-reared neighbors: The migrants were just as likely to have had some employment in the preceding year. (No measure of current unemployment was taken). If employed, they

[3] See Table 1 for selected characteristics of the adult Negro population by migration status in 1967.

were somewhat more likely to have had full-time work (50–52 weeks) and less likely to have "white collar" jobs or to work in the industries in which such jobs are most common, such as trade, public administration, or professional services. Their most common work was as operatives in manufacturing industries.

Despite some overall disadvantage in education and job structure, black urban families headed by a migrant of rural origin did not experience lower average income than other black urban families. Their median (in 1966) was $5,116, compared with $5,105 for the families with urban native heads. A factor acting to produce this parity of income was the more normal composition of the rural migrant families. Seventy-four percent of them had a male head, compared with 69 percent male heads among the urban native families. Families headed by males had double the average income that families with female heads had. When families are considered separately by sex of head, the urban native families headed by men averaged about $300 more in median income than the comparable rural migrant families. A similar difference was indicated for families headed by women but was not statistically reliable.

Among persons living alone or with nonrelatives—the group called unrelated individuals in census data—the rural-urban migrant group averaged somewhat less income than urban natives. The income superiority of the urban natives among unrelated individuals held for both men and women.

When the income data were related to age and family size the following picture of the incidence of poverty appeared, using the standard federal poverty definitions. Of rural-urban black migrants 17 years old and over, 26.6 percent were in poverty, compared with 26.9 percent of the black urban population of urban origin. In other words, the incidence of income poverty among the two populations was almost identical. Black urban residents of rural origin are not more likely to be poor. This overall identity is *not* the chance product of any systematic pattern of internally higher poverty incidence among the migrants that is masked in the aggregate by structural differences in the two populations.

Needless to say, the black rural-urban migrants have a higher incidence of poverty than their white counterparts, of whom one-tenth were in poverty. But it is only among whites that rural-urban migrants show a consistently greater amount of poverty than urban natives. (The difference among whites is not a major one—10.1 percent against 7.4 percent—but is consistent when further classified by age, marital status, education, occupation, and other variables.)

Despite the fact that a fourth of rural-urban black migrants were in poverty in 1966 their migration seems to have been effective in greatly reducing the level of poverty over that prevailing in rural areas. Of the black population still in rural areas, 57.7 percent—more than double the urban proportion—were in poverty. The median income of rural black families ($2,778) was little more than half that of urban families of rural origin.

The Survey of Economic Opportunity also contains the first national information on receipt of money income from public welfare programs, by migration status. In February 1967 there were in the black urban population 151,000 families and 58,000 individuals of rural-urban migrant status who had received some income from public welfare sources in the preceding year. They accounted for 11 percent of all urban families receiving such assistance and 9 percent of the individuals who did so. Among blacks the rural-urban migrant family or individual was nominally slightly more likely than urban natives to have received welfare income assistance. Such income was received by 17.3 percent of the migrant families and 15.6 percent of the urban natives, and 17.6 percent of the unrelated individual migrants and 14.4 percent of the urban natives. However, these differences are not statistically significant from a sampling standpoint and, if real, would be rather minor in any meaningful effect on welfare programs.

The effective impact of black rural-urban migrants on urban welfare caseloads lies in the low average income levels and higher assistance needs of blacks in general and not in any differential propensity of migrants to need or obtain welfare money. Rural-urban black migrant families were somewhat less likely to have received welfare money than blacks still living in rural areas. In equity the frequency of welfare assistance should have been much greater for rural blacks than it was, in view of their very low average income. But in rural areas only 28 percent of the black families in poverty reported having any public welfare income. Black families of rural origin in the city were

less likely to need welfare assistance than their rural cousins but were more likely to get it when in poverty (42 percent) and received substantially higher average payments.

One major difference between rural-urban black migrants and the population that has remained in rural areas is the rate of childbearing. The number of children ever born per 1000 rural-urban migrant black women 35–44 years old was 3360. This is more than 30 percent lower than the childbearing rate of 4937 children per 1000 black women of the same age who still lived in rural areas. We cannot say how much of the difference is the result of selectivity of migrants at the time of move and how much results from lowered fertility after moving to the urban setting. In any case the lowered childbearing of rural-urban migrants is an important factor in their much lower rate of poverty compared with the rural population, for heavy child dependency is a major feature of Negro poverty. To my own surprise, the fertility of rural-urban black migrants proved to be no higher than that of urban natives (3470 per 1000). I do not believe we have previously been fully aware of the magnitude of fertility selection and/or reduction associated with black rural-urban movement.

A final point that I want to make in this discussion of the characteristics and fortunes of the migrants concerns differences in status by decade of migration. The incidence of poverty for rural-urban migrants who were 30–49 years old in 1967 has been tabulated by the decade in which they made their rural-urban move. Naturally those who had moved earlier would have had more years in which to adjust to the urban environment and advance their incomes. They would also tend to be somewhat older than the more recent migrants, within the age-span limits used. Among black migrants there was no consistent pattern or meaningful difference in the incidence of poverty among those who had moved before 1940, in the 1940's, in the 1950's, or after 1960. The poverty rate was 21.8 percent among those who moved in the 1960's and 18.6 percent among those who moved before 1940. In striking contrast, the incidence of poverty among white rural-urban migrants was strongly associated with decade of move. A phenomenally low 1.0 percent rate of poverty was found among whites who moved to the city before 1940. The rate rose progressively for those moving in succeeding decades to a high of 8.5 percent for the migrants who came in the 1960's.

The general picture that emerges from the Survey of Economic Opportunity material is that black rural-urban migrants, despite a distinct educational disadvantage until recent years, have succeeded in earning average family incomes nearly the equal of that of black urban natives and in doing so have avoided any incidence of poverty disproportionate to that of other urban blacks. Nor do they appear to have any but a marginally greater reliance on welfare income. I doubt that these findings conform to the general stereotype of the economic status of black rural migrants, especially those who have come to northern and western cities from the South. Furthermore, on any available scale of comparison their economic and educational status is far superior to that of blacks still living in rural areas. It is well to reiterate, however, that the black rural-urban migrants are far more afflicted with poverty in the cities than their white counterparts.

The impact of future rural-urban migration of blacks is conditioned by the fact that not more than one-fourth of the total black population (at most) now resides in rural areas, compared with better than one-half in 1940 when the large-scale movement began. The great majority of Negro youth are city-born today. In the future rural-urban migrants will not comprise as high a proportion of the urban population as they have in the recent past; nor will their absolute numbers be as large, for the rural base population is smaller, particularly the farm population from which so many people have come. In addition, nonfarm rural employment is supporting larger numbers of blacks than in the past.

On the other hand, these considerations do not imply that rural-urban outmigration of blacks is over. Several factors insure its continuance in the near future: (1) The fertility of the rural population is still very high in modern terms. The present Negro rural population bears enough children to more than double its size in every generation. This creates a potential labor force growth rate that in most areas far exceeds the capacity of the economy to match it with new jobs and thus leads to outmigration. (2) Negro rural youth have a positive preference to live in urban areas. A recent study of rural high school youth in three East Texas counties showed that 63 percent of

the Negro students wanted to live in a large city. The figure for white youth was only 16 percent [3]. A Florida study showed similar results [5]. The economic status and opportunities of rural blacks are still so inferior to that of the urban population, despite some improvement of rural conditions, that urban areas continue to exert a strong pull for people motivated to improvement of their status.

Beyond these generalizations it is difficult to go at this time. When the 1970 census results are in and we can see what changes have occurred in the size and composition of the black rural population, we shall be in a better position to judge the probable extent and nature of the future flow. There is no question that the vast rural-urban movement after 1940 was the major source of the rapid growth of black urban population and hence was a major contributor to those urban problems associated with black growth and congestion per se, but it was probably not critical to the changed politico-cultural mood and stance of the urban black population.

Most of the current further increase of the urban population is coming from natural increase rather than migration. This point is becoming publicly understood, as is the fact that black urban residents of rural origin were not disproportionately represented in the major riots of late years that stimulated so much belated interest in migration. The period when policy support for programs to benefit rural blacks—and thus perhaps retard migration—could be obtained from urban sources on a self-interest basis was rather brief in its life span. Cutbacks in rural-urban movement now, when the supply of migrants has been somewhat depleted, would be unlikely to have major beneficial effects on efforts to relieve urban congestion or otherwise improve the conditions of urban life.

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Effects of Government Policies on Employment Opportunities for Blacks

George S. Tolley

Just to enumerate ways in which government policies affect employment of blacks calls for considering the entirety of local, state, and federal spending as well as a gamut of laws and other actions. Startlingly few findings are available on the impacts of the policies. Too frequently discussion of the disadvantagement of blacks does not seriously consider policy impacts but degenerates into debating whether to do nothing or everything. Everything includes, but is not limited to, fostering inflation, wage and related labor policies, civil rights measures, credit, black capitalism, education and training, health, housing, revenue sharing and welfare.

The present remarks consider impacts in a short space based on limited evidence available. Nevertheless, in place of a choice between nothing or everything they point definitely to a policy mix entailing, first, abandoning well-intentioned policies with adverse effects and, beyond this, focusing effort more sharply on certain policies offering hope of high payoff.

Employment and Inflation

The idea that blacks suffer disproportionately if there is an increase in total unemployment is germane here in the midst of the fourth major recession since World War II. Every recession is different, and this one has its full share of unusual features. After several years of success in maintaining a high level of employment, the danger finally materialized in the late sixties that aggregate demand increased rapidly for a time without being fully countered by offsetting fiscal or monetary measures. As a result, inflation accelerated and was found not to be readily slowable. Contributing to the recession that became pronounced in 1970 were federal expenditure reductions and the monetary measures taken to fight the inflation. An anomaly is that unemployment, wages, and the price level have all been rising rapidly at the same time. In the past two years, average gross hourly earnings have risen on the order of 6 percent per year, which is just about the same as the rise in the consumer price index [25, pp. S-8 and S-15]. Because of increasing productivity prices can usually be expected to rise 2 percent less than wages, even in the absence of a recession. In a recession one expects prices to fall further behind wages. The expected relation between prices and wages, which is contrary to recent events, emerges from models where wages are assumed to adjust more slowly than prices to changes in demand conditions. Recent models of this kind are found in the literature surrounding the Phillips curve controversy, in which an emerging view is that at best any trade-off between unemployment and inflation is temporary [7, 17]. Clearly the trade-off between unemployment and inflation is not as straightforward as customarily thought.

By historical standards recent events have been unusual in financial markets. In explaining high nominal rates of interest, expected inflation has rightly been emphasized [29]. A case can also be made that underlying conditions leading to higher real interest rates have also contributed to nominal interest rate changes. The most important lesson from recent financial events may lie in the simple fact that high and fluctuating interest rates have been survived without disaster, as have substantial readjustments in stock prices.

These recent events, leading to changes in views on stabilization, suggest needs for new monetary-fiscal policy combinations. A combination that can be recommended is to continue the newer active monetary policy focusing on control of the money supply to help avoid inflation, while at the same time pursuing tax and expenditure policies aimed at income, employment, and related goals. A commitment to perseverance in use of monetary policy to combat inflation would make it prudent at the present time to substantially increase expenditures of help to blacks. While the policy combination could lead to a continuation of relatively high and fluctuating interest rates, this is a minor cost compared to the gains in reduced inflation and increased overall employment from which blacks have so much to gain.

The policy suggestion just made runs counter to some long-standing views. On the other hand, an accepted view reinforced by the current recession concerns workers of low skill. Publicity

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has wrongly given the impression that this recession has been centered on middle class space age professionals. The contrast between experiences of white and blue collar workers is instructive. During the 12-month period ending in October 1970 white collar unemployment rose from 2.4 to 3.2 percent, and unemployment of blue collar workers rose from 4.2 to 7.2 percent. As usual, the concentration of effects has been among blacks, whose unemployment rate rose from 6.6 to 9.3 percent, and teenagers, for whom the rise was from 12.9 to 17.1 percent [25, p. S-13]. Reflecting a compounding of these last two rates, unemployment of black teenagers had risen to 30 percent by the third quarter of 1970 [26, p. 65].

How can these unemployment patterns be explained? Regardless of policies, the average level of unemployment from which any recession starts is relatively great for those less skilled workers who normally have short duration of employment on any one job. In an occupation where duration of jobs is short, more workers at any one time will be looking for a new job. On becoming unemployed less skilled workers probably do not search as effectively in unfamiliar industries and areas as those with more skills. Less skilled workers have fewer jobs of lower skill to turn to and are no doubt less apt at turning to jobs for which they do not have experience. Another reason why unemployment rises more for unskilled workers in a recession is what Lester Telser has called specific human capital (see [15]). Because skilled workers are more highly specialized to their jobs, the costs to employers from hiring and firing them are greater and at least partly explain why highly skilled workers are kept on while those with less skill are fired.

A villain that now enters is minimum wages. The accumulating evidence that minimum wages have deleterious effects on less skilled workers [5, 8, 14, 16] is consistent with a straightforward theoretical argument, namely wage above equilibrium. Tortuous lines of reasoning are required to escape concluding that minimum wages contribute to umemployment of less skilled workers. Similar remarks could be made about other labor policies and about some activities of unions.

Aside from the implication that further increases in minimum wages are undesirable, two more constructive policies are implied. Both are prime candidates for inclusion in the fiscal policy suggested above. First, blacks would gain much from an expanded and federalized unemployment insurance program to help cushion effects of employment fluctuations. Second, the effects of minimum wages give stronger reasons than ever for government expenditure programs aimed at increasing employment of less skilled workers.

So far, programs aimed at unskilled workers have emphasized training. In 1970 a manpower bill nearly became law that would have provided substantial federal funds to employ the workers [20]. A consolation in the delay is that time may be gained to improve design. The employment programs raise problems of slippage, efficiency, and logistics. The slippage problem is how to increase employment without incurring large expenditures for those who would be employed anyway. The efficiency problem is how to ensure that the expenditures result in a worthwhile product. Employment in health occupations is most frequently mentioned as a worthwhile focus. The logistics problem is how to organize so that jobs and people will mesh and so that the program will be self-liquidating if the need diminishes. A policy that rates high in ability to meet all three problems is a variable wage subsidy. The subsidy would apply to classes of workers identified each quarter as having high unemployment rates and would vary with their rate of unemployment. It could be restricted to certain industries and occupations, or it could be available across the board to any employer.

Spatial Impacts of the American System[1]

Much attention has been given to the tendency for employment to grow in suburbs and other places outside the central cities, while blacks remain concentrated inside central cities partly because of housing discrimination. One result of this spatial pattern is diminution in access of blacks to jobs, particularly for those without cars. Other results are lack of access to higher quality of education for children and to public services generally and a socially undesirable racial apartness with a growing spectre of black reservations ringed by white suburbs. There is lack of understanding of reasons for the spatial pattern, particularly in quantitative terms. Consequently, the effectiveness of pol-

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[1] This section emphasizes blacks, whereas an earlier paper, "Implications of the Urban Crisis for Rural America" [24] was concerned with the way some of the same considerations affect rural people.

icies aimed at influencing the pattern is difficult to judge.

The spatial separation of blacks and whites has not yet been changed by civil rights policies in any overall way. According to Taeuber [21, p. 220], from 1960 to 1969 the central cities had an increase of black population of 2.6 million and a decrease of 2.1 million in white population; as a result, while blacks comprised 12 percent of the population of metropolitan areas in 1969, they accounted for 21 percent of the population of central cities and 5 percent of suburban rings. The major change since 1960 has been an increase in percentage of blacks in the central cities. According to Taeuber, "nearly three-fourths of the total national growth in the Negro population since 1960 has occurred in the central cities of the metropolitan areas." It is true that "available evidence indicates some increase also in the number of Negroes in the suburban areas, but the numbers involved are still so small that it is difficult to establish the size of this increase."

A full list of reasons for existing patterns extends far beyond policies overtly concerned with segregation. Movements of people are not directly controlled; but many community, city, and state decisions influence where people live. Incentives under this system affect resource allocation and income distribution in ways that can be understood by starting from a pure case and introducing successive complications. If all group expenditures were for public services paid by marginal user charges and, even more extremely, if people did not need to live near where they work, their choices of where to live would lead to clustering into communities where everyone desired the same bundle of public services. Each community in the country would consist entirely of residents who were exactly alike in their income and tastes. Between communities there would be complete stratification of people. The situation would be optimal from a resource allocation point of view. Tiebout, who emphasized this theory [22], was influenced by observing people choosing where to live among a variety of suburban communities. Unfortunately for the theory, differences among suburbs explain at best only a part of the variation in local public expenditure. Because travel costs limit the distance people live from work, because people of different income levels are complementary in production, and because there are economies of scale in a spatial context in supplying public services, the complete stratification envisaged in Tiebout's too simple world does not occur. People of differing income and tastes do in fact live within the same taxing and spending jurisdictions.

In spite of this complication, a resource allocation optimum might still be achievable for services financed by charging users extra costs of providing service to them. A concomitant complication to be considered, however, is the income distribution motive important in many public expenditures. Relief and welfare are outright income redistribution, and additional income redistribution is accomplished through collecting less in taxes than the costs of education and other public services supplied to poorer residents. It follows that the degree of stratification among communities will affect the degree of income redistribution. More redistribution is likely, the greater is the degree of income inequality within a community. Higher income people can avoid having income distributed away from them by segregating themselves into communities lacking poorer people, and the automobile has made this easier. Zoning and codes restricting the supply of housing demanded by lower income people are among the policies used by richer communities to exclude poorer people.

Financial incentives to move away and exclude people give impetus to a stratification of people beyond the point that is desirable for resource allocation or income distribution aims. People travelling far to work and in some cases being unemployed are examples of resource allocation costs resulting from efforts to avoid income redistribution. Even if the present degree of income redistribution is accepted as most desired, the redistribution could be achieved at less cost if carried out in a way that did not lead to the extra stratification now incurred to escape it. Studies of location of jobs and residences by race, e.g. [11], suggest that the potential cost reduction may be great. There is, furthermore, reason for believing that the costs incurred to avoid the burden of income redistribution lead to a less than optimum degree of income redistribution. Income redistribution is a public good and leads to free rider problems. People favor it, but everyone else shares in the good of one person's contribution. The social benefit from a person's contribution to income redistribution is thus greater than the benefit felt by the contributor. This view of income redistribution is implied by Becker [1] and Hochman [10], who have not, however, been

concerned with the spatial implications. If people were unable to move, community decision through local government could hope to avoid the free rider problem. Moving to another taxing jurisdiction is a way of avoiding the consequences of the community decision.

The discussion so far has concentrated on pocketbook motives affecting stratification of people into communities. Further reasons for believing there is overstratification have to do with people's tastes. Stratification is affected by the fact that people's satisfactions depend on who their neighbors are. As long as people's tastes are accepted, this influence increasing stratification need not be considered undesirable in itself, though it probably heightens the tendency toward a less than optimal amount of income redistribution. People's tastes have a public good quality. The collective outcome of these tastes may have undesirable effects which no individual has much incentive to take into account in his own acts. Attention has been given to the idea that people in their choice of neighbors exhibit racial discrimination. The view that racial discrimination is undesirable gives another reason to suppose there is overstratification. One could go further and postulate that to avoid separation of people into isolated groups the degree of mixing in communities of people of differing income and ethnic groups is a social end in itself. The idea that mixing is desirable, beyond the point to which it would be carried by people even in the absence of racial discrimination, provides yet another reason for believing local decisions lead to overstratification.

These remarks have stressed how expenditures below the federal level lead to an American style apartheid for both pocketbook and taste reasons. Federal expenditures also contribute to the apartheid. Federal income tax laws that encourage home ownership because of interest deduction in F.H.A. mortgage insurance have favored growth of single-family suburban housing for higher income whites who otherwise would have stayed renting in the inner city. A study by Wyatt Mankin indicates that the pronouncedly lower rate of home ownership for black than white families is explained for the most part by income and other nonracial characteristics, but some effect of the race variable is also evident suggesting discrimination [13]. The study suggests that the tendency for blacks to be bottled up in central cities is increased by black lack of financial resources for home ownership, relative to higher income families favored by federal government policies.

Condominium laws, making possible home ownership in multifamily structures, favor black ownership to some extent and allow whites to own in modern apartment buildings in the city center. Experimental subsidies for acquiring home ownership under Section 235 of the housing act undoubtedly encourage some greater degree of mixing of races by giving lower income blacks financial options to move into single-family neighborhoods. However, the mixing effect seems likely to be minor. The major effect may be to make for ownership rather than rental within predominantly black neighborhoods.

Federally sponsored public housing projects have led to greater isolation of poor people in areas within cities where thousands of people nearly all down and out live, in place of a situation where the housing would have been older but would have had a greater mixture of people of different income and social strata. Proposals for undertaking more of these projects in suburbs miss the point unless the need for changing their character is also recognized. The proposals for subsidies for low-income housing in suburbs do have something to recommend them over "stick" programs that make federal aid contingent on a "workable program" or have more overt sanctions. On the other hand, turning urban renewal into a low-income housing program will not do much to help blacks; for whatever else can be said about urban renewal, it encourages more mixing by making central cities attractive to higher income persons.

The major impacts of the federal government have just begun to be considered in this discussion. Effects of transportation policy, particularly urban expressways, have been twofold in opposite directions. By providing better access, expressways increase the possibility of speeding to and from work in the central cities while living in suburbs. On the other hand, the expressways have retarded decline of economic activity in the central cities, making for more city job opportunities for blacks and for tax revenues for public services benefiting central city blacks.

The largest spatial effects of the federal government may come from the discretion in the entire remaining part of the federal budget. In recent years the geographic impacts of de-

fense and space age spending have received publicity, but these provide only recent dramatic examples. There is establishment bias in the discretion used in deciding where federal expenditures will be made. The nuclear accelerator being built in Weston, Illinois, is illustrative. The accelerator was built in Illinois is illustrative. The accelerator was built in Illinois partly in order to try to disperse to the Midwest some of the federal science expenditures concentrated on the west and east coasts. In the decisions as to where within the Midwest to build the facility down to many details of construction, it appears that elites were involved whose interests prevailed over those of lower-income groups. This extended to the obliteration of the town of Weston itself, which was a low-income community [12]. This is a case history illustrating a principle.

The Gains to Blacks from Reducing Discretion

Since black power—evinced either through voting strategy or through protest actions—does not compare in strength to white power, blacks seem bound to lose in the game of discretion. A way to win is to play a different game. A promising approach is to have more government spending decisions made on the basis of quantitative estimates of contributions to objective criteria, reducing scope for discretionary decisions which tend to favor established people of influence and not blacks. Most federal expenditures are made now with no necessity for serious evaluation. The criteria should include contributing to national income. Employing persons who would otherwise be unemployed or, if employed, would be in less productive work is one way to contribute to national income. Several years of concern with Appalachia and other lower-income nonmetropolitan regions have led to development of techniques for estimating the contribution of spending to national income through reducing unemployment and underemployment [9, 23]. Application of these methods to all federal expenditures should result in increased employments of blacks, in view of the present concentrations of unemployment and low earnings among them. The increased employment in tax jurisdictions where blacks live would increase local tax revenues, enhancing local capacity to provide quality education and other public services. Recognition is needed that a goal is to achieve a higher degree of mixing of families of differing income and ethnic backgrounds, as emphasized in the preceding section. Meaning ful measures of degree of mixing can be con structed and estimated for all kinds of federa spending.

Each type of spending has its own evaluatio problems. For a discussion of a type of spendin for which objective evaluation has lagged, se the views of Richard Muth and myself in th recent report of the Presidential Task Force o Urban Renewal [18]. The Office of Managemen and Budget, as an instrument of the Presiden speaking for the nation and not for particula interests, could be empowered to require tha all federal expenditures be subjected to quanti tative estimation of impacts on national goals Responsibility for development and enforce ment of evaluation methods should be at centralized level with the executive branch t ensure uniformity and to protect against bia that creeps in if methods are left to agencie that identify with interests benefited by them Quantitative evaluation has by now becom sophisticated for some types of expenditures particularly water resource projects, as il lustrated recently in attempts by the Wate Resources Council [27].

There is at least equal scope for applying ob jective criteria below the federal level. A fur ther important benefit would be to increase th efficiency with which state, city, and com munity services of particular importance t blacks are carried out. The benefits would b especially great at the present time when de mands are increasing in the face of difficultie in raising revenues. The work of RAND fo New York City is an example of efforts o larger municipalities to bring more analysi into local government expenditure decisions Even for larger cities the surface has hardl been penetrated. For smaller municipalities particularly in the more rural parts of th country, a case can be made that more tech nical assistance is needed for community ex penditure decisions. Because each communit is too small to justify elaborate evaluatio studies, a pooling of efforts for planning o common problems appears justified. The plan ning is impeded by a lack of methods for es timating quantitatively the benefits of th gamut of local expenditures and would be a worthy focus of research effort.

Policy Mix

While the need for more objective evaluation of expenditures is great, even with the best

advances to be hoped for, gains to blacks from such reform could take a long time to materialize. More pointed and larger efforts are needed to improve their position in a reasonably short period. At the extreme of pointed efforts is the complex bag of stick programs epitomized by civil rights legislation providing for sanctions against discrimination in voting, housing, and employment. On net these measures have undoubtedly increased opportunities for blacks. A question of importance is how far they can be pushed without inviting more backlash than they are worth. Without increasing reliance on stick programs, the major way a near-term improvement for black opportunities seems possible is through increased spending. Several of the arguments made earlier come together to focus on revenue sharing. If carried out in a way to reduce disparities in public service levels among jurisdictions, it could help eliminate some of the apartheid tendencies inherent in the American system of public finance. A desirable approach would be to allocate federal funds on the basis of need, geared to the difference between the tax revenue people bring to a community and the local public expenditure for public services supplied to them. A corollary from the discussion of the desirability of objective criteria for spending is that the expenditures should carry requirements as to evaluation, using quantitative measures of contributions to national goals. These considerations suggest, then, not block grants to state capitals, but grants to communities within states according to needs, conditional on objective efficiency tests and provided for specific purposes.

In addition to the unemployment and wage subsidy programs mentioned, several other kinds of expenditures should be emphasized. The evidence becomes most meager when one tries to estimate where the highest payoffs in different kinds of public spending occur. In the absence of this evidence it may be hypothesized that in terms of contributing to national goals both of income and opportunity, human resource expenditures have a high payoff, as do to a lesser extent direct efforts to attain a more equal income distribution.

What Kinds of Human Resource and Income Distribution Measures?

The lack of knowledge about effectiveness of alternative approaches to improving human resources is almost amazing, given the many programs and experiments of the last ten years ranging from job training to federal aid to public education. It is true that the programs have been examined to the extent of revealing that the cost is high for a neighborhood youth program largely devoted to paying a living stipend rather than giving education and that a given proportion of trainees obtained a job at the end of training. These findings, however, do not permit reliable conjectures about the comparative contribution of programs of the last decade to national goals. Methods for doing deeper analyses are available, as illustrated in [2] and [4], but few meaningful studies are available that throw light on the comparative effectiveness of different approaches.

Estimates have been obtained indicating that returns to general public education are substantial [19]. A defensible hypothesis is that some of the most productive expenditures leading to better job opportunities for blacks would be on general primary and secondary education, with a broad interpretation given to the concept of education. While the delay in payoff of measures for children is longer than for adults, ten years is not a long time within which to make progress, given the magnitude of the problem.

The Coleman report [3] may be cited as an extensive study concerned with race and general education. It indicates that integration has a small but positive influence on student performance. Most important for the present discussion, socioeconomic background of parents is a chief explainer of school performance. If education is interpreted to mean preparation for life, the most overwhelmingly important part of education takes place in the home. The finding that socioeconomic background explains much variation in student performance suggests that education in the home and education as traditionally given in schools are complementary. An implication is that general education, if increased, should not simply give more of traditional kinds of education. Much of the lack of opportunity for blacks comes from cultural deprivation, which is to say a lack of education in the home. Public school expenditures that attempt to substitute at school things missing in the home environment have much to recommend them.

A characteristic of earnings of blacks noted by several persons, e.g. [6, 28], is that returns to education appear lower than for whites. Earnings tend to rise the more education a black has

had, but not as steeply as for a white. This pattern might be taken as evidence that the the returns from more general education would not be effective in increasing economic opportunities for blacks. Such an argument is justified if lower earnings of blacks are due to job discrimination. However, job discrimination is lessening, and there are two other reasons that may be more important in explaining the flatter education-earnings profile of blacks. Poor quality of education of blacks in the past could explain the lower returns if education is measured simply as years of schooling. Past concentration of black education in the rural South, where education expenditures per pupil are low and where there have been poor teachers perpetuating low quality, suggests that poor quality may be important in explaining apparently low returns to black education. The evidence then does not contradict the contention that there would be high returns to improving the quality of education of blacks. The hypothesis that there is complementarity between home and formal education could also help to explain the apparently low returns to education of blacks. Improving general education is the only approach among those reviewed in this paper that is directed at the major root of inequality for blacks, namely cultural deprivation.

If these arguments are accepted, income distribution measures are desirable but receive lower priority than education measures. Income measures can help to some extent to increase informal education in the home because more family income enables more education within the home, perhaps most directly in enabling the mother to spend more time with the children. However, income redistribution is a trickle-down approach to education and does little to upgrade the quality of the teachers in the home who are the culturally deprived family members.

Conclusion

Policies that would be favorable to blacks have been discussed here qualitatively. Expanding unemployment insurance and initiating variable wage subsidies would have rather immediate effects. Abandoning ill-advised labor policies may offer hope in a longer term. Also in the longer term, spatially equalizing expenditures having income redistribution impacts would reduce tendencies toward stratification harmful to blacks. Blacks should be helped by reduction in discretion in all types of government spending. Most hope rests in human resource programs with payoff in the intermediate term of, say, a decade.

Modest shifts in voting strengths could make possible substantially increased expenditures for programs discussed in this paper. Assuming such voting shifts eventually occur, what course will then be desirable? In view of the inadequacies of the evidence, there is much scope for disagreement. The prevailing estimates of respectable returns to education, in face of vast increases in education over the past several decades, give a presumption that returns would diminish little as a result of large expenditure increases. A subjective judgment is that a package possibly well over $30 billion that emphasizes education and manpower measures, with particular efforts to make up for home lacks, could dramatically improve the economic position of blacks and could be easily justified in terms of contributions to national goals.

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Economic Position and Prospects for Urban Blacks

Phyllis A. Wallace

This report examines some current economic problems and prospects of urban blacks. Extrapolation of present trends on income and wealth, occupational distribution, etc., will not significantly narrow the black-white economic gap. In fact, there could be one kind of future for the middle class, educated, highly mobile blacks and another for that majority now isolated in the nation's ghettos. Their futures are one, however. The positive indications of this outcome are briefly sketched below.

Economic Problems

By most measures of economic well-being (statistics on size and distribution of income and wealth, employment status, entrepreneurial activity, etc.), blacks are substantially worse off than whites. In 1969, 71 percent of all blacks lived in metropolitan areas with 56 percent in central cities and 15 percent in the suburban rings. Blacks accounted for 21 percent of the total population in central cities and 5 percent of those in the suburbs. Slightly more than half of all blacks lived in the South with the latter group divided more or less evenly between metropolitan and nonmetropolitan areas [7, pp. 4–9].

The relatively poor economic status of blacks is associated with the following:

(1) Blacks constitute about 11 percent of the civilian labor force, receive somewhat less than 7 percent of aggregate money income, and have less than 2 percent of all assets owned by American households. In their examination of data from the Survey of Economic Opportunity, Brimmer and Terrell found that in 1966 the average net worth of white urban families ($19,278) was more than five times greater than the average net worth of black urban families ($3,407). The disparity in net worth revealed considerable understatement of the economic position of blacks [1].

(2) Blacks are at a serious disadvantage relative to whites in the labor market: They have greater underemployment and higher rates of unemployment, are less likely to be covered by collective bargaining agreements, and are in low-wage industries that offer the least opportunity for training and upgrading. It is surprising to note that there has been rejoicing because the ratio of the black to the white unemployment rate has dropped to less than 2 to 1 and that a disproportional part of the increase in joblessness has been borne by white collar employees and/or white workers. The unemployment rate for white adult male workers in SMSA's with population of 250,000 or more increased from 1.8 percent in the fourth quarter of 1969 to 3.9 percent in the fourth quarter of 1970. The rates for black males in these areas moved from 2.6 percent to 5.0 percent during the same period [8]. These aggregates may obscure unemployment of long duration and lack of labor force participation for blacks, especially in urban poverty neighborhoods.

(3) Black urban families are larger and a higher proportion of these families are headed by females. The proportion of black families in metropolitan areas headed by females was more than three times the proportion of white families headed by women [7, pp. 16–36].

(4) Despite high levels of economic activity in the mid-sixties and some improvement in the educational attainment of blacks, the relative income differences have not improved. In 1968 the income per family member for blacks was 55 percent of that of whites in metropolitan areas. If these observed income ratios are adjusted to reflect poorer net worth status, the per capita income for urban black families might be no more than 50 percent [4].

(5) In many cases attainment of moderate income levels for black urban families requires a greater effort. In 1968 the median income of black families with two earners was less than white families with a single earner ($7,910 compared to $8,422) in metropolitan areas. Within the black community the "talented third" make it into the middle class; the rest, greatly impoverished, lag far behind. Only 29 percent of black families in central cities, and with male heads, had income of $10,000 or more.

(6) Although some blacks residing mainly in suburban rings and smaller metropolitan areas

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escaped from poverty during the period 1959–1968, blacks accounted for a larger proportion of the poor population in metropolitan areas in 1968 (32 percent) than in 1959 (29 percent). Children under 18 years old accounted for almost three-fifths of all poor blacks in metropolitan areas.

(7) Residential segregation creates a highly visible geographic separation which serves to maintain status exclusiveness. It also results in de facto segregation of black urban families in schools, restricts access to employment in outlying areas, and encourages overcrowding and deterioration which contribute to a high rate of disease and crime.

(8) Patterns of employment discrimination have not been significantly changed in most industries [9]. The 1967 report on job patterns for minorities and women prepared by the Equal Employment Opportunity Commission noted, "Not only was the overall minority representation slight, it was not significantly related to the degree of need for improvement. Industries where minorities enjoyed greatest increases in representation were not industries where their representation was lowest in 1966. Thus, the general pattern was for improvement to occur in industries where minority representation was already above average. . . . Disproportionately few officials and managers were members of minority groups. In the occupation where hiring, firing, and promotion and decision-making take place, minorities were even more underrepresented than in other white collar occupations."

(9) Blacks have been effectively excluded from significant participation in program resources of the public sector. The delivery of a full range of community services has not been equitable.

Prospects

Are the economic prospects for urban blacks as bleak as the present data might indicate? Thurow has noted that whites seek to maximize their economic gains from discrimination. These gains and the desire of whites to increase their social distance between the races are the major barriers to attaining black/white economic equality [5]. Despite the estimated 25-year lag of black incomes and the substantially poorer net wealth position of black families, some improvement of the economic status of blacks within the last third of this century may occur. This is a long-run view. It does not predict that parity in employment or income will be achieved in three decades, but only that some gains in the economic status of urban blacks may be associated with some specific structural developments.

I shall discuss only six positive indications of movement toward significant economic and social change for urban blacks. The list could be expanded and perhaps given some rank order in terms of extent of expected status improvement. Increased cohesion within the black community, the dynamics of the youth revolution, the growth of labor unions, the more perceptive socially oriented activities of business, diffusion of training techniques within the civilian sector of the economy, and the formulation of comprehensive long-term programs to upgrade the quality of life may produce beneficial results for blacks.

Ethnic cohesion.—With the recent intensification of racial polarization, blacks have started to define new modes of conduct relevant to their lives. Black caucuses in a number of organizations are manifestations of concern over group identity, status, and survival.

Youth revolution.—Erik H. Erikson's "Memorandum on Youth—Toward the Year 2000" noted that "the ethical questions of the future will be less determined by the influence of the older generations on the younger ones than by the interplay of subdivision in a life scheme in which the whole life-span is extended; in which the life stages will be further divided; in which new roles for both sexes will emerge in all life stages. . . . In the next decade, youth will force us to help them to develop ethical, affirmative, resacralizing rules of conduct that remain flexibly adjustable to the promise and the dangers of worldwide technology and communication" [2]. These rules of conduct may determine a more humanitarian acceptance of low-status individuals in this society. The economic consequences may precede the social reorganization.

Growth of labor unions.—I anticipate a much more positive role for trade unions in helping to advance the economic status of blacks. As blacks move into more highly skilled jobs or as they participate more fully in some of the growth sectors, particularly the service industries, unions will view them as likely recruits for membership. There has been considerable debate about the construction unions and their role vis-a-vis minority apprentices and journeymen. Surely within the social sci-

ence community someone could design a program to persuade the white journeymen of today that as their own sons and younger relatives move up into white collar jobs, they could pass the skills of the trade along to "apprentice sons" who would be minority youngsters and would not be a direct threat to their present jobs.

Socially oriented business.—Many employers who are locked into central cities and find it difficult to flee to the suburban fringe have started to investigate how they might best train and utilize the minority manpower now residing in these areas. For example, if some of the public utilities had anticipated a decade ago the problems and financial burden of recruiting and training both skilled and low-level white collar employees, they would have followed a different path to the 1970's.

Diffusion of training techniques.—There will be some diffusion in the civilian sector of techniques utilized to excellent advantage in the military. In 1966 the Department of Defense established Project One Hundred Thousand. The objectives of the program were to upgrade skills and improve education of large numbers of youngsters who would have been disqualified for military service because of their educational deficiencies. Almost a quarter of a million young men were accepted into the program by 1969, and about 40 percent were minority (mostly black) [3]. These young men were returned to civilian life with skills needed to pursue successfully a number of jobs. Their records should tell us much about on-job training and job performance.

Long-term program.—On December 31, 1970, the President signed the Housing and Urban Development Act of 1970 [6]. Title VII, the Urban Growth and New Community Development section, represents a major new resource for improved life opportunities for urban blacks. The Federal Government will assume responsibility for development of a national urban growth policy which should: (1) foster continued economic strength of all parts of the United States, including central cities, suburbs, smaller communities, local neighborhoods, and rural areas; (2) treat comprehensively problems of poverty which are associated with disorderly organization and rural decline; (3) refine the role of the Federal Government in revitalizing existing communities and in encouraging planned, large-scale urban and new community development.

The emphasis of this law will be on offering heterogeneous populations more choices for urban living. As centers for community services, environmental resources, economic and financial activity, and as focal points of political and socio-cultural values, new communities can offer blacks significant economic and social benefits.

Perhaps the most powerful forces noted above are noneconomic. I hope that economists will not become so enamored of sophisticated models that they fail to review their basic assumptions.

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Research Notes

The Use of Discriminant Analysis in Selecting Rural Development Strategies*

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IN THE Joint Task Force report entitled *A National Program of Research for Rural Development and Family Living* [3], we are reminded:

> Billions of dollars are being spent in the United States in attacking problems of families, communities, and the environment, and greater amounts may be needed in the future. In both current and projected situations, funding and program measures are being pursued without the required research and evaluation for effective and efficient policy formulation and direction. Scores of millions of dollars could be saved or used more effectively with measures based on the fundamental knowledge which research can furnish [3, p. 1].

The central theme of this paper is that one area of "required research for effective and efficient policy formulation" concerns the need to help those rural areas interested in increased economic activity to identify the most *feasible* of the range of *possible* strategies that they might pursue. It seems that much less research has been conducted on what is feasible for a community to achieve than has been conducted on what the residents of that community want to achieve. While local support is necessary for bringing about increased economic activity, it is not sufficient.

In the following I shall illustrate how discriminant analysis can be of use in assisting rural areas to discern their comparative advantage. Prior to treating the actual problem it is necessary to describe, very briefly, the essence of discriminant analysis.

Discriminant Analysis

Discriminant analysis has grown out of interest associated with assigning an unknown object to one of G mutually exclusive groups on the basis of a set of n measurements on that object [9]. Instead of analyzing data to decide in which group an individual or object will be superior (perform best), the problem is concerned with deciding which group an object or individual is *most like*.[1] For the former, regression analysis is appropriate; for the latter, discriminant analysis is relevant; the group to which an object or individual belongs is paramount, rather than some measure of relative efficiency within the group.

In 1936 R. A. Fisher hypothesized that a linear function, y, of the variables x_i $(i=1, 2, \cdots, n)$ such that $y=v_1x_1+v_2x_2+\cdots+v_nx_n$, would be a function capable of discriminating among groups [2]. The coefficients (v_i) of the linear function y are computed so that the ratio of the sums-of-squares between group means to sums-of-squares within group means is maximized. This ratio can then be used as a basis for a test of the hypothesis that the two points representing the position of the n means of the groups in the n-dimensional space occupy the same point for the populations under consideration. The linear function that maximizes this ratio is the discriminant function. There is no other linear combination of the

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[1] Some relevant applications of discriminant analysis have recently been conducted by Blood and Baker to help classify ranches in the northern Great Plains between "wheat" and "cattle" [1]; by Prescott and Lewis, to analyze locational incentives among various areas [6]; and by Reinsel, to classify potential F.H.A. borrowers [7].

n variables which has the discriminating power of this one function [8, 9].

To be less abstract, assume there are two groups, A and B, containing N_g ($g=1, 2, \cdots, k$) objects each, with each object being scored on each of n characteristics. Upon computing the discriminant function for this set of objects,[2] at least two interesting analyses can be carried out. One possibility is to measure these same variables on an object of uncertain group identity, substitute these values into the discriminant function, and, based upon whether $y \lessgtr y^*$, place the object in the appropriate group (A or B).[3] That is, if $y > y^*$ the object most resembles those objects in group A, while if $y < y^*$ it most resembles those in group B. The second possibility is to compute the "scaled coefficients" to discern the relative importance of the variables $x_1, x_2, \cdots, x_n$ in discriminating between membership in group A or B. That is, one can rank the n variables in descending order of their relative contribution to determining proper group membership.

There are other statistical tests that can be conducted, but these two are of immediate relevance.

Empirical Application

The problem of discerning the subset of feasible alternatives for a group of rural communities can best be illustrated by restricting the range of choice. That is, the approach here will be limited to illustrating how discriminant analysis can help distinguish between "recreation" and "industry."[4] As a starting point, the 72 counties in Wisconsin were ranked on the basis of proportion of wholesale and retail services classified as catering to recreation users[5] and on the basis of per capita income derived from manufacturing.[6] The 11 counties with the largest proportion of the former index were combined into a "recreation" group (R). For the latter ranking, the top 20 counties were not included here since they comprise the highly industrialized counties along Lake Michigan. The following 17 counties were defined as being not highly urbanized or industrialized, yet as having achieved certain success in attracting industrial activity. These will be called M.

There are hence two mutually exclusive groups of counties, one group oriented primarily to servicing recreationists, the other consisting of primarily rural counties that have managed to attract some industrial activity. Because the dominant forces in achieving some greater degree of economic activity usually are in attracting tourists or industry of some kind, an important issue is to help aspiring counties to decide which route is most feasible for them in terms of a greater probability of success and, by implication, which group (R or M) they *most resemble*.

The first step in analyzing the current problem is to develop the criterion by which inferences can be made as to which group, R or M, an individual county most resembles. To accomplish this, 20 variables were hypothesized as possibly having a bearing on a county's presence in group R or M, and each of the 28 counties was scored on these variables.[7] These variables appear in in Table 1, along with two coefficients to be explained below. The column "discriminant function coefficients" contains the coefficients for a linear function $y = v_1x_1 + v_2x_2 + \cdots + v_{20}x_{20}$, which were so computed that the ratio of the sums-of-squares between group means to the sums-of-squares within group means is maximized. That is, there is no other possible linear combination of the 20 variables that will discriminate between groups R and M with the same level of confidence as y.

Once the discriminant function has been derived from the sample of counties in the two groups, it is possible to select a county not in-

[2] There will always be one less discriminant function(s) than there are groups to discriminate among. See [8].

[3] y^* is the "critical value" of the discriminant function. With three groups, there would be two discriminant functions and two critical values, with four groups there would be three functions and as many critical values. To compute y^*, the overall group means are substituted into the discriminant function for the x_i's.

[4] It is possible to expand the range of possible choices to more than two; this will be elaborated upon below.

[5] More specifically, this is the number of hotels, motels, tourist courts, camps, and amusement and recreation places as a proportion of the number of total service establishments. The difference consists of personal services, miscellaneous business services, auto repair, miscellaneous repair service, and motion picture theaters [5].

[6] That is, value added by manufacturing on a per capita basis [5].

[7] For those inclined to denounce this as inductive empiricism, Northrop [4] would be instructive. He effectively destroys the myth that there is but one "scientific method" and argues persuasively that the scientific maturity of the particular intellectual endeavor defines the appropriate method. For those "young" endeavors still searching for deductively formulated theorems, Northrop calls this the "natural history stage" of inquiry. Its components are primarily observation, description, and classification.

Table 1. Variables for 28 Wisconsin counties with the discriminant function coefficients and the scaled vector coefficients

Variable number	Discriminant function coefficients	Variable	Scaled value
1	.21	percent of land in forest	22.35
2	−.07	allowable cut/forested acre	−14.49
3	.20	distance to nearest city of 25,000–100,000	36.34
4	−.01	distance to nearest city of 100,000–250,000	− 1.45
5	−.12	distance to nearest city of >250,000	−26.90
6	−.15	through traffic volume	− 9.30
7	.03	distance to nearest Interstate highway	9.09
8	.00	acres of lakes in county	4.65
9	−.01	miles of trout streams in county	− 6.43
10	.25	percent of county land in public ownership	17.81
11	−.00	value of agricultural products sold	− 5.21
12	−.14	distance to nearest 4-year campus	−15.15
13	−.12	distance to nearest 2-year campus	−14.32
14	−.02	distance to nearest vocational school	− 1.73
15	.48	distance to nearest major health center	37.84
16	−.47	distance to nearest major airport	−44.89
17	.33	distance to nearest shipping port	44.95
18	−.45	distance to nearest ski area	−29.08
19	.12	distance to nearest major recreation site	14.16
20	.05	per capita tax levy	6.27

cluded in these two groups, one for which information is desired on its most feasible strategy, and score it on the same 20 variables. Substituting these values into the discriminant function, that county receives a discriminant score (y_i). The next step is to compare this with the critical value of the discriminant function, y^*. The critical value is computed by substituting overall group means into y for the x_i's. If $y_i > y^*$, the county in question most resembles those in group R; if $y_i < y^*$, it most resembles those in group M. For the present problem, $y^* = 15.59$.

Discriminant analysis can also indicate which of the 20 variables are most important in determining a county's resemblance to the two groups. The scaled coefficients in Table 1 indicate which variables have relatively more influence in placing a county in its appropriate group. The largest positive-valued coefficients, variables 17, 15, 3, 1, 10, and 19, are most important in placing a county in R; the largest negative-valued coefficients, variables 16, 18, 5, 12, 2, and 13, are are most important in placing a county in M.

Implications

To recount briefly, rural areas in search of greater economic activity have a range of possible strategies they might pursue. Among these there is one strategy which, on the basis of its particular set of characteristics, a given region may pursue with the greatest probability of success.[8] Additionally, discriminant analysis can indicate which of the variables measured were of greatest weight in placing the region in its "proper" group. By implication, then, it also indicates the most significant variables for placing it in another group. That is, as in the example here, if a region were "assigned" to group R but its residents wished instead to attract manufacturing, they might safely conclude that the addition of a nearby major airport (variable 16) would be the most important factor for moving them into (making the region resemble those in) group "M."

While the problem was here illustrated as a binary choice, it is possible to have three choices, say "one-day recreation," "overnight recreation," and "long-term recreation." Then the scaled coefficients would indicate the necessary attributes to enable a region most like those with "one-day recreation" characteristics to become most like those able to induce people to stay for one or more nights. Addi-

[8] When discriminant analysis is used to advise entering college freshmen which "career group" they most resemble there is nothing that indicates effective demand for their services. Likewise, its use here abstracts from the issue of "regional demand" for recreation services or manufacturing sites. The determination of comparative advantage by using discriminant analysis may be thought of as fulfilling the necessary conditions for greater economic development, but nothing more. The sufficiency test requires knowledge of regional excess capacity (or lack thereof) in providing recreational services and the knowledge of "footloose" industries seeking new locations.

tionally, more than one set of strategies might be employed in which recreation potential is represented by one continuum and industrial potential by another ("labor-oriented" vs. "materials-oriented"). This would indicate which of the various types of recreation enterprises and industry groups the region possessed the greatest comparative advantage for, based upon other regions' success in these various groups.

In conclusion, there is no pretense that this is a definitive work in the effort to identify the comparative advantage of Wisconsin counties.[9] The intent has been to call to the attention of scientists working in the general realm of rural development a statistical technique long used by educational psychologists for telling entering college freshmen which of five or six career groups they *most resembled;* that is, alerting the student to *his* comparative advantage. The hypothesis here advanced is that this problem is not unlike those of rural communities seeking some degree of increased economic activity. Just as discriminant analysis is useful in the former endeavor it can be useful in the latter as well.

[9] The indices used here are not the result of extensive literature review but were selected as ones easily obtainable through secondary sources, for the sake of example.

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Analysis of Milk Production Costs Using Cross-Section Data: The Problem of Converting Observed Quantities of Milk to a Standard Butterfat Content*

J. Bruce Bullock

Analysis of milk production costs using cross-section data is complicated by the need to convert observed quantities of milk to a standard butterfat content. This need arises because the market price per hundredweight of milk is a function of its butterfat content. In other words, the market treats milks of different butterfat levels as if they are different products. Meaningful analysis of costs can be developed only for standardized units. Calculation of average production costs per hundredweight of milk using unadjusted quantities is not unlike estimating the average cost of producing a unit of automobiles and horses.

This problem has been widely recognized by economists. Few, if any, analyses have failed to convert observed quantities to standard units. The fat corrected milk (FCM) procedure developed by Gaines [2] is widely used by economists for this purpose. This procedure, however, compounds the problem it is intended to solve and introduces a bias into the cost analysis. The purpose of this note is to demonstrate the nature of this bias and to suggest a more appropriate standardization procedure for use in economic analysis.

The butterfat level selected as the base is arbitrary. This selection, however, defines the quantity adjustment factor to be used in the ensuing cost analysis. Once the base butterfat level is selected, only one price is relevant in calculating total and net revenues—the blend price of the base level milk. Moreover, total revenue on farm i, TR_i, is an observed quantity. Its value is unchanged as a result of the ex post facto and arbitrary selection of a unit of measure for milk. Therefore the implied total revenue (blend price of base level milk$\times$adjusted quantity) must be identical with the observed total revenue.

The constraint can be expressed as follows:

$$(1) \qquad P_kQ_i^* = P_k rQ_i^j = P_jQ_i^j = TR_i$$

where

k is the base butterfat content

P_k and P_j = the price per hundredweight of k and j percent butterfat milk, respectively

$Q_i^* = rQ_i^j$ = quantity adjusted to standard base, k percent hundredweight

Q_i^j = observed quantity of j percent butterfat content milk on farm i

r = quantity adjustment factor, and

TR_i = total revenue on farm i.

It is clear from the above identity that the adjustment factor, r, must be P_j/P_k. Any other adjustment factor will yield a different implied total revenue and the results will no longer be consistent with observed data.

Given k percent butterfat as the base, $Q^* = (P_j/P_k)Q_i^j$ is the unit of milk on which the market calculates returns (i.e., total revenue $= P_kQ^*$). Therefore, unless average and marginal costs are calculated for the same units, comparison of per unit costs and returns are meaningless.

The overriding constraint on a standardization procedure used in economic analysis is that it not distort measures of economic efficiency. In particular, the relative efficiency of alternative economic activities should be no different after standardization than in the original data. Cost per dollar value of output TC/TR is a measure of economic efficiency. Clearly, any adjustment procedure for which implied total revenue does not equal actual total revenue will lead to changes in the efficiency indicator. The price ratio adjustment procedure is consistent with identity (1) as shown above and thus leaves the original efficiency ranking unchanged. It is now shown that the FCM procedure biases the efficiency indicator in favor of milk with butterfat content above the base level. The FCM procedure involves selecting some butterfat content (k) as the base (e.g., 4.0 percent) and converting the observed quantities to k percent FCM units [4]. For example, 100 pounds of 3.5 percent milk would be converted to Q' units of 4 percent FCM as follows: $Q' = 100(.4+.15(3.5)) = 92.5$ pounds. Thus on an

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FCM basis, 100 pounds of 3.5 percent milk is equivalent to 92.5 pounds of 4 percent milk. By comparison, the price ratio method (using 1969 blend prices for North Carolina) defines

$$\frac{\text{blend price 3.5 percent milk}}{\text{blend price 4.0 percent milk}} \times 100 = \frac{7.0864}{7.3864}$$

$\times 100 = 95.4$ pounds of 3.5 percent milk to be equivalent to 100 pounds of 4.0 percent milk.

Thus, although 100 pounds of 2.5 percent milk has the net energy content of only 92.5 pounds of 4.0 percent milk, it has 95.4 percent of the value of 100 pounds of 4.0 percent milk.[1] The FCM procedure clearly discounts milk on the basis of butterfat content at a different rate than the pricing mechanism. As a result, average and marginal costs calculated on the basis of FCM units result in biased estimates of net returns because costs and revenues are measured in different units. Only if the market discounts milk solely on its net energy content will the two procedures be identical.

The possibility of pricing milk on the basis of its protein and nonfat solids content in addition to (or in lieu of) butterfat continues to be discussed. If these changes are adopted, the FCM procedure will clearly be useless for economic analysis since it would reflect only one physical dimension of the product. However, the price ratio method will correctly reflect all *economic* dimensions of the product regardless of the basis of the discount.[2] Thus, the price ratio method will continue to be a valid adjustment procedure for economic analysis. Any attempt to develop a standardization procedure based on the physical dimensions of milk will lead to biased cost estimates similar to the FCM procedure unless the pricing mechanism perfectly mirrors the physical relationships.

[1] The adjustment factor defined by the price ratio procedure will of course differ for each market. North Carolina prices are used only as an example. The fact that the adjustment factor will differ between points that have different prices is of no consequence. Comparisons of these points can be made by taking account of the differences in their price ratios. A more detailed comparison of the two adjustment procedures using data on North Carolina dairy farms can be obtained by writing to the author

[2] After this note was developed I found a study that used the price ratio procedure to adjust quantities [3]. The FCM procedure continues to be used, however (see [1]).

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Use of Linear Programming in Capital Budgeting with Multiple Goals*

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Capital budgeting is concerned with choices among alternative investment opportunities. These investment opportunities include not only business decisions, such as which plant to build and hence which new technology to adopt, but also the amounts to be spent by government on roads, education, research, military facilities, and the like. Given this wide definition of investment alternatives, capital budgeting can be seen to be one of the most important economic activities in both the private and public sectors.

Capital budgeting decisions almost invariably involve multiple goals, whether they are made in the public or private sector. The existence of multiple goals plus the difficulty that one man or even the several members of a management team may have in comprehending all the implications of all the available alternatives calls for the utilization of a systematic methodology in making capital budgeting decisions.

The use of linear programming as the systematic methodology to assist in the analysis of capital budgeting problems has been suggested by Baumol and Quandt [3] and Weingartner [7], among others. These authors did not, however, discuss the ubiquitous problem of multiple goals in capital budgeting. In this paper, we propose to extend their work by developing a method of solving capital budgeting problems that involve multiple goals.

It should perhaps be emphasized that the use of linear programming does not allow a reduction in the work of budgeting the detailed implications, particularly the cash flow implications, of alternative investment decisions. Budgeting, if done comprehensively, is extremely time consuming, since for each possible physical investment there may be several alternative ways of financing the investment and accounting for it for tax purposes. Each of these combinations of investment, financing, and accounting will have a different impact on the firm's after-tax cash position; hence each has to be treated as a separate investment alternative.

Conscientious budgeting of investment alternatives, however, will not lead to automatic selection of the "best" set of alternatives. A conceptual framework is also required to deal with these questions:

(1) How should the firm reconcile its conflicting goals?
(2) How should investment indivisibilities be handled?
(3) How far forward should investments be budgeted?
(4) How should price and technical variability be handled?

Only the first question relating to goals is considered in this research note. Since some goals cannot be brought directly into relationship with the measuring rod of money, a method is proposed to measure these nonmonetary goals. A linear programming model is then introduced and an adaptive "black box"[1] technique suggested to reveal the decision maker's preference function with respect to the multiple goals. An orderly search procedure is then introduced to permit estimation of the "efficient" capital budgets that would result from changes in the preference function. An efficient capital budget is defined as one for which it is impossible to increase the score of any one goal without lowering the score of some other goal.

The Problem

In general, capital budgeting with multiple objectives can be expressed as an integer nonlinear programming problem: Find the $1 \times k$ vector of activities and investment levels x, such that:

$$Z = z(g_1(x), g_2(x), \cdots, g_n(x)) \quad \text{a max} \tag{2.1}$$

subject to:

$$h_i(x) \leq 0 \tag{2.2}$$

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[1] The term "black box" is used for any procedure for converting input into output when the actual procedure for making the conversion is either unknown or unimportant. The term "adaptive" implies some element of feedback, so that each lot of output from the black box allows us to define a "better" set of input.

and

$$(2.3) \qquad x \geq 0$$

and some elements of x integer,
where

$g_j(x)$ the jth goal function; $j=1, \cdots, n$,
$h_i(x)$ = the ith restraints on the investment alternatives and resulting cash flows; $i=1, \cdots, m$,
$x = k \times 1$ vector of investment alternatives and investment levels, and
Z = some function, probably nonlinear, of the level of individual goal functions.

If the individual functions, $g_j(x)$, $h_i(x)$, and the objective function, Z, are known a priori, the capital budgeting problem can be analyzed by any of the complicated search procedures suitable for integer nonlinear programming.

We are concerned with the less general case in which (1) the restraints on the investment possibilities (2.2) can be expressed as, or approximated by, linear inequalities; (2) the individual goal functions, $g_j(x)$, can be expressed on an arbitrary linear scale; and (3) a local maximum of the objective function (2.1) is the global maximum and the direction of improvement of the function can be determined at any point.[2]

The first of these qualifications implies that restraints (2.2) can be replaced by a set of linear inequalities:

$$(2.4) \qquad Ax \leq b$$

where

A is a $m \times k$ matrix of the cash flows and flows and technical coefficients of the investment alternatives, and
b is a $m \times 1$ vector of restraints on the cash flows.

The second of these qualifications, that $g_j(x)$ can be expressed on a linear scale, presents few problems when the goal function is one that is typically measured in monetary terms. All that is required is that the function be linear in money, or that \$50 has a utility exactly five times that of \$10.[3] When the goal function cannot be easily measured in monetary terms, an arbitrary scale must be devised. This scale must meet the requirement that if we designate specific "bad" and "good" outcomes of the jth goal as, say, 0 and 100 respectively, then any other outcomes can be placed on the resulting scale and the preferences thus expressed are additive.

Suppose, for example, that one of a firm's objectives is to minimize pollution, and there are two investment alternatives: (1) a large sewage installation that would *improve* water quality leaving the plant, and (2) an addition to the plant that would not affect water quality leaving the plant but would add to air pollution.

The arbitrary scale might then assign 0 to do nothing (adopt neither project), and -100 to the air-polluting project. We then require that the improved water quality project can be placed, say, as $+20$ on the resulting -100 to 0 scale and that if *both* projects are undertaken their results would be additive on the scale (or $-80 = -100 + 20$).[4]

It is important to note that in the above example the two projects do not need to fall on any technical or financial continuum. The improvement in the "pollution level" resulting from improved water quality is not technically comparable with the decline in the pollution level because of increased air pollution. What we require here is a judgment by the decision maker that from the pollution viewpoint the deterioration in the environment caused by the air pollution project would be five times the magnitude of the improvement in the environment achieved by the sewage treatment project. This judgment is made in only the "one dimension" of the level of pollution. The decision maker need not determine which of the two projects he prefers overall; he has only to order

[2] That is, given any solution, x^*, the corresponding gradient vector:

$$v_x^* = \left[\frac{\partial z^*}{\partial g_i}\right]$$

can be evaluated. Note that we have not assumed that (2.1) itself is linear, merely that a gradient vector can be obtained and that a local optimum is a global optimum.

[3] Not all monetary goals will necessarily fulfill this simple requirement. It may be that \$5 million is not thought to be exactly five times as worthwhile as \$1 million. In that case even the monetary goals will need to be converted to a linear scale, as discussed below.

[4] Nonadditivity can easily be handled by defining mutually exclusive investment opportunities. If, in the example cited, the two projects gave a pollution score of -60 (rather than -80) on the established -100 to 0 scale, we could define *three* investment projects: (1) sewage plant, as before (score $+20$); (2) air pollution, as before (score -100); (3) sewage plant and air pollution (score -60); with the added requirement that, at most, one of these projects might be selected.

them linearly with respect to the particular goal currently under discussion.

The procedure calls for linearizing (or scoring on a 1 to 100 scale) each goal function, one at a time and in isolation. We are not at this stage judging any desirable trade-off between goals. It may be that with a total pollution "score" of 5000, the decision group would willingly pay $1 million to reduce the score by 100, even though with a total pollution score of 1000 they would pay only $.1 million for a further reduction of 100. The estimation of appropriate weights (in the light of the level of the goal fuuctions) is a major concern of this research note and is discussed below.

If the decision maker cannot provide even a tentative estimate of this "one-dimensional" information, it is obvious that the derivation of anything approaching an optimum capital budget would be extremely difficult. Certainly it would lie outside the scope of this paper.

The third qualification, that the direction of improvement of the objective function (2.1) can be specified at any point by the decision maker, enables us to use a search procedure to derive a sequence of improved capital budgets. The related assumption, that a local optimum is a global optimum, ensures that the terminal point of such a sequence will be the global maximum. If there are several local optima or the decision maker cannot specify the direction of improvement of the capital budget, the problem would likely require a very sophisticated model rather than the conceptually simple model proposed here.

Definition of Goals

The goals of the capital budgeting problem may be set by an individual or a group;[5] but in practice, a group or committee is likely to have much more difficulty than an individual in defining goals. As a basic procedure, therefore, it is suggested that several appropriate goals be agreed upon, an arbitrary but appropriate scale established independently for *each* goal, and individual projects then numerically scored in terms of their effect on *each* of these goals. For a planning committee of a company, for example, it is plausible that in addition to "profit" (probably itself a multidimensional concept), the group might agree upon the goals of minimizing pollution, improving the company's community relations, and increasing the company's technological sophistication. For each goal, two basing point projects would be clearly defined and assigned, say, scores of 0 and 100. All other projects would then be scored in terms of the arbitrary scale thus established. There is, of course, no need to use the same basing point projects to define all scales; rather, projects that have a dramatic effect on the particular goal should be used. Building a sewage plant would likely be a relevant basing point on the pollution scale, whereas sponsoring an athletics team might be an appropriate basing point for the community relations scale.

Reaching agreement on scoring of projects on the established scales is bound to be a major task involving disagreement and compromise. No claim can be made that establishing these scores is likely to be simple; it is claimed only that the suggested procedure provides at least some hope that the team will arrive in roughly the right ball park. Disagreements can arise among the committee members over the contributions of different projects to specified goal functions or because the goal function may encompass incommensurables, such as air and water pollution, on the same scale. If a serious conflict arises in the definition of the goal functions, it may be resolved in one of two ways: (1) expanding the number of goal functions to achieve a set for which reasonable agreement on scaling can be achieved; or (2) accepting more than one scaling of the goal function and running the capital budget for each scaling.

Both suggestions really involve shifting the conflict from the specification of the problem to the interpretation of results. If, for example, the pollution goal is replaced by separate water pollution and air pollution goal functions and agreement on the scaling of these functions is achieved, a conflict may still arise later as to the relative importance of these two goals. In the same way, if different scalings for the pollution function are accepted, conflict may arise as to which of the resulting capital budgets is the best. By delaying a decision on the relative importance of competing goals until trial capi-

[5] We note that we desire only to approximate the goal function set for the group of people actually able to make the relevant capital budgeting decisions. Thus, the fact that other people, in other situations, would rank outcomes quite differently is irrelevant if they have no power to affect the actual decisions under examination. When the preferences of other individuals can be imposed (by local or federal regulations for example), these outside preferences will usually be expressed as restraints on the capital budgeting alternatives.

Table 1. Schematic representation of simplex tableau for capital budgeting

Objective: Maximum		0	0	⋯	0	0	0	⋯	0	⋯	1	λ_1	λ_2	λ_3
		ACTIVITIES[b]												
Restraint[a]	B	Project 1.1	2.1	⋯	Bank	Project 1.2	2.2	⋯	Bank	⋯	Cash	Dividend	Asset	Pollution
Initial cash	100,000 ≥	2000	7000	⋯	100	0	0	⋯	0	⋯	0	0	0	0
⋮														⋮
Tax-free $cash_1$	50,000 ≥	−500	2000		−103	2000	7000		100		0	1	0	0
Tax-free $cash_2$	−10,000 ≥	−700	−10000		0	−500	2000		−103		0	2	0	0
Final cash	0 ≥	−1000	−10000		0	−700	7000		0		1	0	0	0
Final assets	0 ≥	−1500	−5000		0	−1000	5000		0		0	0	1	0
Pollution	0 ≥	−20	100		0	−20	100		0		0	0	0	1

[a] Subscripts 1, 2, ⋯ denote the level of these constraints at the *end* of years 1, 2, ⋯ respectively
[b] For i·j indexes on projects, i indicates the project number and j the year it is initiated.

tal budgets are available, it is hoped that the chances for agreement will be enhanced. It is easier to choose between two alternatives than to provide a comprehensive set of decision rules for making the choice.

In summary, the simple specification of relevant linear goal functions should not be an insuperable task, even for a committee. In any case, if consideration of the resulting capital budgets convinces the decision makers that they have misspecified their objectives, they can always reinitiate the analysis using more appropriate goal functions.[6]

Profit as a Multiple Goal

The discussion has concentrated on multiple goals that cannot easily be brought directly into line with the measuring rod of money. It is perhaps worth pausing to point out that, in the context of capital budgeting, profit itself is a "multiple goal." It is reasonable to suppose, for instance, that the following four frequently conflicting objectives are components of the traditional goal to "maximize profits":

(1) Maximization of the dividends paid to shareholders;[7]

(2) Maximization of "net tax free cash" available to the firm at the end of the planning period;

(3) Maximization of the value of assets owned (or controlled?) by the firm at the end of the planning period; and

(4) Minimization of the probability of financial collapse of the firm during the planning period.

Thus, *a firm cannot avoid the problem of multiple goals in capital budgeting by deciding to concentrate on the "single" objective of profit maximization.*

Similarly, much of the argument on the best single criterion for capital budgeting is irrelevant: The *n* dimensions involved in the objectives of capital budgeting cannot be mapped into a single dimension by any simple transformation such as payback period, internal rate of return, or even discounted cash flow. For this reason some discussions of the best (single) criterion for capital budgeting are reminiscent of the theories advanced by two-dimensional Flatlanders, when faced with a three-dimensional object [1].

Linear Programming

The capital budgeting problem can now be formulated in a multiperiod linear programming framework modified to accommodate multiple goals. The programming tableau is illustrated in Table 1. Four goal functions are included in this formulation: dividends paid to shareholders, net tax-free cash at the end of the planning horizon, value of assets owned at the end of the planning horizon, and pollution.

It is assumed in the illustration that two investment projects and the opportunity to put cash in the bank are available activities in each period (projects 1 and 2 in this illustration

[6] If King Midas had had the advantage of modern computer analyses available to him, he probably would have put some side conditions on his goal of being able to change things to gold after seeing the results of his first "run."

[7] Even this objective can be interpreted in a number of ways, since dividends are paid in different time periods (not to mention cash or stock) and different people may have different time rates of discount for future dividend payments.

refer to the sewage installation and plant addition discussed earlier). Activities are also included to accumulate dividends, final cash, final asset value, and pollution levels generated by the program. The final cash, final asset value, and pollution activities are constructed so that these activities take one unit of cash, assets, or pollution from the appropriate row and reflect it in the objective function. The dividend activity can be structured in a number of ways, depending on the firm's objectives. In Table 1 it has been assumed that the B column includes the cash withdrawal needed to maintain dividends at their present levels.[8] Thus, the dividend activity indicates *planned increases* in the level of dividends, and the firm wishes any such increase to be scheduled at a steady (linear) rate.[9]

The restraints included in the model refer to initial cash availability; tax-free cash at the end of years 1, 2, 3, etc.;[10] and final cash, final asset value, and pollution levels at the end of the planning horizon.[11] The B column interfaces the capital budgeting decision with the other operations of the firm. The coefficients in this column reflect the projected cash surpluses that would be generated in future years by the *current* level of capital stock minus cash withdrawals for dividend, tax, and overhead payments consistent with current policies. Thus, the firm has $100,000 of cash at the beginning of the planning horizon, and it is expected to generate $50,000 in year 1 and to want to withdraw $10,000 in year 2 with the current level of assets.[12]

After-tax cash flows resulting from any particular investment alternative can be represented as technical coefficients in the tableau.[13] The after-tax gain in cash deposited in the bank is set at only 3 percent, on the assumption that the difference between 3 percent and the bank's interest rate is taken in taxes.

The objective function in Table 1 includes only four nonzero entries, one for each of the four goal functions. The entries λ_1, λ_2, and λ_3 refer respectively to the weight the firm attaches to increasing the dividend payment, final asset value, and decreasing the pollution level, relative to increasing the amount of final cash.

An Adaptive Black Box

The linear programming procedure described above will yield an efficient solution to the capital budgeting problem for any levels of λ_1, λ_2, and λ_3, the relative weights assigned to the goal functions. As defined here, an *efficient solution* is achieved when it is not possible to improve the score of any one of the individual goal functions without lowering the score of at least one of the other goal functions. Even given that an efficient solution can be obtained, there is still the problem of deriving the efficient solution preferred by the decision maker or decision-making unit, which amounts to using the right relative weights (such as λ_1, λ_2, and λ_3) in the objective function.

The approach proposed here is an iterative approach using both the decision makers and the linear programming analysis as "black boxes" with the output of one used as input to the other.[14] Initially an efficient capital budget

[8] The firm is willing, if necessary, to sacrifice all growth in order to maintain *current* dividends. Thus, there is *no* acceptable trade-off between reducing dividends below current levels and increasing final cash. If trade-offs are permissible, payment of dividends at the current level should be included as an activity.

[9] In setting up the capital budgeting problem the firm does not know whether it will be able to allocate $10 or $10,000 for *increased* dividends in year 1, but its preference function is such that if it allocates an extra $10 for year 1 it wants to allocate an extra $20 in year 2 and $30 in year 3. That is, it wants to *increase* dividends at a steady (linear in this case) rate.

[10] If the firm is not in the maximum tax bracket, it may be desirable to incorporate in the analysis a calculation of the taxes the firm should aim to pay in each year. To do this we simply incorporate "Before-tax cash" restraints with transfer activities into the "Tax-free cash" rows. If the first $10,000 pays tax at the rate of 25 percent, the first taxation transfer activity (limited to $10,000) would take $1 from the "End-of-year cash" row and deliver 75 cents into the "Tax-free cash" row for the beginning of the next year.

[11] Additional technical restraints can be added—such as limiting the program to initiating Project 1 in year 1 or year 2 or year 3 and controlling borrowing activities to available amount or debt-equity ratios.

[12] This interface is crucial to the capital budgeting analysis. It is quite conceivable that the future cash flows from the other operations of the firm will influence the current investment decision. For example, if a temporary loss from other operations is projected for next year, cash may be put in the bank to cover that projected loss rather than invested in equipment during the current year.

[13] If we make investment i, if we use financing system j, and if we depreciate according to schedule k, then the cash flows in the first, second, third, etc., years will be.

$$a_{ijk1}, a_{ijk2}, a_{ijk3} \cdots .$$

This is the sense in which the cash flows are described as being "technical." They follow from conscientious application of budgeting procedures.

[14] Other approaches have been suggested to establish the weights for goal functions and checking their internal con-

for a specified set of relative weights of the goal functions would be presented to the decision makers. The decision makers would then be used as a black box to tell us the direction of the relative changes in the weights which they think would lead to an improved solution. If they can not do this directly, parametric programming in the neighborhood of the suggested weights would indicate the rate of substitution between different goal functions; for example, how much increased pollution must be sacrificed to increase the final asset value of the firm. The decision makers could then decide whether a shift in that direction is desirable. If so, new sets of budgets in that direction could be programmed and reexamined in the same way. *In this way we can feel our way towards an optimal capital budget without ever explicitly defining the decision maker's preference function.* The sequential identification of improved capital budgets would be continued until a budget is found that is better than all adjacent budgets or until the rate of gain in the objective function is lower than the per unit cost of further analysis.

The specification of initial weights for the alternative goal functions may be difficult. It should be noted, however, that since we propose a sequential analysis for a problem for which it is assumed that a local optimum is global, the starting point is not really terribly important. We could, for instance, start by maximizing final cash and then increase the weights of those goals which were felt to have outcomes at too low a level in the cash-maximizing capital budget. Some guide to the appropriate weights may be available by quite simple a priori considerations. In the pollution example cited earlier, the air-polluting project was given a score of -100 on the pollution scale. If the decision makers feel that, ceterus paribus, they would be willing to forego this project if it does not add at least \$20,000 to final cash, the implication is that the initial weight for the pollution goal might well be set at \$200 of final cash per unit.[15]

sistency, notably the Churchman-Ackoff Value Measure [2].

Conclusion

This paper has shown that mathematical programming can be used to generate efficient capital budgets for capital budgeting problems involving multiple goals. Iterative confrontation of decision makers with the resulting efficient capital budgets has been suggested to give improved estimates of the relative importance of competing goals. In addition, it has been shown that capital budgeting decisions can be interfaced with the other operations of the firm. The suggested approach is thought to constitute a major break with the independent, one-dimensional analyses used in payback, internal rate of return, or even discounted cash flow procedures of capital budgeting. The internal rate of return is not even implicitly fixed, but rather is discovered (and may vary between time periods) as a result of the iterative redefinition of the decision maker's goal weights.

[15] Ceterus paribus, the effect of introducing the air-polluting project is to *lower* the objective function by 100 λ_3 in Table 1. In the suggested example, the decision makers start by feeling that they would be indifferent to use of this project if it increased final cash by only \$20,000. Hence, for our initial estimate we believe that $\$20{,}000-100\lambda_3=0$ is a break-even value of λ_3; or $\lambda_3=\$200$ is a break-even value of this weight.

Note that this is not \$200 per \$1 of expenditure on pollution, but \$200 of final cash per unit of the arbitrary pollution scale which was established by giving the air-polluting project a score of 100. There is no direct connection between our procedure and information that could be obtained on a cost accounting basis. While the *initial* estimate of the weight to be given to the pollution goal may be \$200 per unit, it may subsequently emerge that, in the light of the other weights used and the production possibilities, the optimum weight may be found to be, say, \$50.

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A Note on Fluctuations in Supply and Farmers' Income*

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IN DISCUSSIONS about short-run fluctuations in the supply of agricultural products, it is commonly implied that because of the low elasticity of the demand for such products, fluctuations bring about a deterioration in farmers' average income. Such a statement is misleading and at best incomplete without further information about the shape of the demand function over the relevant range.

The correct conditions for the farmer to benefit from output instability have been stated by several authors [2, 3, 5, 6]. The purpose of this note is to examine the relationship between the shape of the demand function and farmers' income. It will be shown that concavity of the total revenue function is the important concept and not the elasticity of demand. Thus, with linear demand functions, supply fluctuations will cause a decline in farmers' average income, whether price elasticity over the relevant range be greater or smaller than one. In contrast, when the demand function is of the constant elasticity type, average income will increase when elasticity is smaller than unity and decrease when it is greater—quite contrary to common belief.

In part I the main results are formally derived, and in part II an empirical application is presented.

Let us assume a perishable crop, with supply fluctuating around the average quantity $\overline{Q}$ at regular intervals w. The market supply curve is completely inelastic and so the demand curve determines the price and revenue at each period.

Let the demand function be

$$P = f(Q) \tag{1}$$

and let T and M denote total and marginal revenue, respectively, and η the price elasticity of demand defined as $\eta = -(dQ/dP)(P/Q)$.

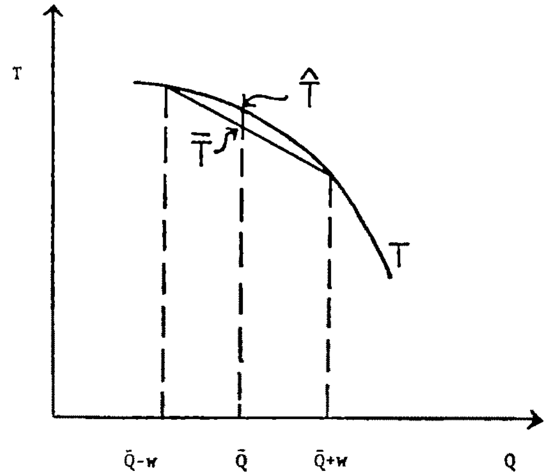

Figure 1

In any particular period i, farmers' total revenue will be

$$T_i = P_iQ_i$$

and average revenue over n periods, which we shall denote by $\overline{T}$, will be

$$\overline{T} = \sum \frac{P_iQ_i}{n}. \tag{2}$$

If crops were supplied to the market in a constant flow, disregarding cost of storage, mean-crop revenue, denoted by $\hat{T}$, would be

$$\hat{T} = f(\overline{Q})\overline{Q} = \overline{PQ} \tag{3}$$

where $\overline{P}$ is the price corresponding on the demand function to $\overline{Q}$.

The higher-crop period will produce a greater revenue for the farmer when $\eta > 1$ and a smaller revenue when $\eta < 1$.

As can be seen from Figure 1,[1] the *mean-crop revenue* ($\hat{T}$) will exceed the *effective mean-revenue* ($\overline{T}$) (i.e., fluctuations will cause a reduction in income) as long as the total revenue curve is concave. This implies that the marginal revenue

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[1] We deal here with only two periods for the sake of simplicity. The analysis can be generalized assuming Q_i to be distributed according to a given density function with $\overline{Q}$ as its mean. The analysis would not be changed, but on the empirical part we would have to assume Q_i and e_i (the random error in the demand regressions to be estimated) to be independently distributed.

is downward sloping, as it is usually assumed to be and is invariably so drawn. Assuming now P to be a decreasing monotonic twice differentiable function of Q, we have

$$M = T' = P + P'Q \tag{4}$$

or

$$M = P\left(1 - \frac{1}{\eta}\right) \tag{4'}$$

$$M' = 2P' + P''Q \tag{5}$$

Therefore, if the demand has a negative slope ($P'<0$) fluctuations will reduce average income ($\hat{T} \geq \overline{T}$) if

$$-\frac{P'}{QP''} \leq \frac{1}{2} \tag{6}$$

which is always the case for linear or concave to the origin demand curves[2] ($P' \leqq 0$).

The constant elasticity function is frequently used in empirical demand studies. It is therefore interesting to examine it in the present context, especially since it yields quite unconventional results.

Derivating (4′) with respect to Q with η being constant by assumption, we find

$$M' = P'(1 - 1/\eta) \tag{7}$$

That is,

$$\overline{T} \gtreqless \hat{T} \text{ as } \eta \lesseqgtr 1.$$

The surprising conclusion is that under these demand conditions farmers' revenue will rise as a result of supply fluctuations when price elasticity is *smaller* than unity and fall when it is greater.

II

Let us now illustrate the implications of crop fluctuations in agricultural short-run supply with an empirical example. The data are taken from a recent study of demand functions in the cooperative vegetable wholesale market in Tel Aviv [1] and refer to October–November of 1964.

Daily data of the quantities of grade A tomatoes brought to the market and the prices obtained through auction sales were examined. Three subgrades (A-1, A-2, and A-3, in descending order) were considered, over a time span of seven weeks. Separate functions were estimated for the three subgrades, and dummy variables introduced to take care of the week effects.

Thus we have[3]

$$\ln P_{gij} = a_g \ln Q_{gij} + \sum_{i=1}^{7} W_{gi}D_{gi} + e_{gij} \quad (j = 1, \cdots 5) \text{ for each } g = 1, 2, 3 \tag{8}$$

where

P_{gij} = observed price of grade g in day j of week i;

D_{gi} = dummy variable for week i in the regression for grade g;

e_{gij} = random error of gijth price.

Let us assume that tomatoes could be stored over the week to provide an even daily flow equal to the week's average. (Since there are only five market days, this is a reasonable assumption.) The effective mean revenue for each grade and week would then be equal to

$$\overline{T}_{gi.} = 1/5 \sum_{j=1}^{5} P_{gij}Q_{gij} \quad \text{(for given } g \text{ and } i\text{)} \tag{9}$$

and over the whole period

$$\overline{T}_{g..} = 1/35 \sum_{i=1}^{7} \sum_{i=1}^{5} P_{gij}Q_{gij} \quad \text{(for given } g\text{)} \tag{9'}$$

The weekly mean-crop revenue would be

$$\hat{T}_{gi.} = \hat{P}_{gi.}\overline{Q}_{gi.} \quad \text{(for given } g \text{ and } i\text{)} \tag{10}$$

where $P_{gi.}$ is the price on the estimated demand function corresponding to the mean-crop $\overline{Q}_{gi.}$ and the mean-crop revenue over the whole period

$$\hat{T}_{g..} = 1/7 \sum_{i=1}^{7} \hat{P}_{gi.}\overline{Q}_{gi.} \tag{10'}$$

However, the latter expression cannot be compared outright with (9′) because of the random error e. Rather, it must be compared with what farmers could expect under "normal" market conditions, i.e., prices corresponding on the estimated demand function to the observed daily quantities, eliminating the respective week effect. Let us call this quantity the *esti-*

[2] The expression in equation (6) can be identified as the elasticity of the marginal demand curve (P'). J. Robinson used the same concept in a different context [4] and referred to it as a measure of "the adjusted concavity of the average curve" (p. 40).

[3] The model is specified without an intercept because otherwise the ($X'X$) matrix would become singular in the presence of dummy variables. An alternative procedure is to leave the intercept and delete one of the dummy variables.

mated mean revenue, denote it $\tilde{T}$, so that for each week and grade we have

$$(11) \qquad \tilde{T}_{gi.} = 1/5 \sum_{j=1}^{5} \hat{P}_{gij} Q_{gij} \qquad \text{(for given } g \text{ and } i\text{)}$$

$$(11') \qquad \tilde{T}_{g..} = 1/35 \sum_{i=1}^{7} \sum_{j=1}^{5} \hat{P}_{gij} Q_{gij} \qquad \text{(for given } g\text{)}$$

The results obtained for the whole period, in I. L., are summarized below:

	Symbol	Grade A-1	Grade A-2	Grade A-3
Adjusted price elasticity[4]	η	17.2	7.0	8.6
Effective mean income	$\bar{T}_{g..}$	13,004	18,574	19,322
Estimated mean income	$\tilde{T}_{g..}$	12,990	18,725	19,925
Crop-mean income	$\hat{T}_{g..}$	13,080	19,075	19,995
Ratio $\bar{T}/\hat{T}$		.9942	.9737	.9663
Ratio $\tilde{T}/\hat{T}$		.9931	.9816	.9650

If we assume profits to be 20 percent of revenue, a difference of 4 percent in TR (as for grade A-3) would represent a 20 percent difference in profits, which appears more impressive than the .965 $\tilde{T}/\hat{T}$ ratio.

The $\tilde{T}/\hat{T}$ ratio depends, besides of the value of η, on the variance of the crops around their mean.

The averages (for the seven weeks) of the standard deviations of Q_j around their means for the three different grades of the empirical part are: grade A-1, 3.9; grade A-2, 7.4; grade A-3, 10.5. The large standard deviation for grade A-3 partially explains its relatively low $\tilde{T}/\hat{T}$ ratio.

Finally, whereas for $\eta > 1$ the relative differences are small, they are much greater for $\eta < 1$. These relationships are illustrated in the following table, computed for a simple two-period model with relative fluctuations of 10 percent and 50 percent and price elasticities of 5 and 1/5:

Value of $\tilde{T}/\hat{T}$, in two-period case, for

	$\eta=5$	$\eta=1.5$
$w=0.1$	0.999	1.11
$w=0.5$	0.979	8.10

This explains the low ratios of estimated to crop-mean revenues obtained in the empirical data cited above and the between-grade differences of these ratios that, in turn, depend on the price elasticities and crop fluctuations observed in each case.

Evidently, the empirical value of these results depends on the accuracy of the estimated demand functions, because both the numerator and the denominator of these ratios are computed at estimated daily and weekly price levels, respectively. However, the fact that $\bar{T}/\hat{T}$ does not differ significantly from $\tilde{T}/\hat{T}$ seems to imply that the estimation is acceptable. As was shown in the preceding sections, the sign and magnitude of these ratios depend on the functional model assumed to represent the true market situation.

We pointed out that had we estimated linear demand functions, the outcome—fluctuations causing losses—would have been actually assumed. The constant elasticity model used in the empirical part is free of this charge, and therefore its results as to the negative effects of fluctuations are easier to accept. There is one further question, however, whose answer depends again to a large extent on the functional form assumed. Having found the harmful effects of fluctuations, some sort of mechanism to even out the marketable flow (like cooperative storage) would seem to be justifiable. But what is the maximum that we should be willing to pay for such a service? The answer depends on the magnitude of the $\tilde{T}/\hat{T}$ ratio. For comparative purposes only, we calculate these ratios from a linear-demand model:

Grade	slope (dP/dQ)	η (at $\bar{Q}$, $\bar{P}$)	$\tilde{T}$	$\hat{T}$	$\tilde{T}/\hat{T}$ Linear	$\tilde{T}/\hat{T}$ Double log
A-1	−.6245 (t=1.7)	8.91	13,005	13,305	.9775	.9931
A-2	−.6479 (t=4.8)	4.73	18,574	19,872	.9347	.9816
A-3	−.2177 (t=3.1)	6.90	19,232	20,141	.9594	.9650

[4] In estimating the equations, lnP was used as dependent variable. The "adjusted price elasticity" in the text is therefore the reciprocal of the estimated coefficients. The estimated regression coefficients and their t ratios are:

Grade	$1/\eta$	t
A-1	.058	(1.3)
A-2	.143	(4.6)
A-3	.116	(3.0)

The dummy variables were in all cases significant.

We see that cases could arise, depending on the cost of the storage services, under which econometrician A, having chosen a double log model, would reject the storage program as too costly, while econometrician B would favor it based on his linear demand calculations.

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EDITOR'S NOTE: This section of the *American Journal of Agricultural Economics* may include comments on the replies to previous articles and other literature in agricultural economics, suggestions for improving the effectiveness of the AAEA, discussions of changes in emphasis needed within the profession, and contributions on other topics of interest and importance to agricultural economists. Manuscripts submitted for this section should be prepared in accordance with the guide appearing on the inside of the back cover of this issue and should not exceed 1,000 words.

Communications

PROGRAM DEVELOPMENT IN THE NATIONAL BUREAU OF ECONOMIC RESEARCH

Recent planning and research activity at the National Bureau of Economic Research involves significant expansion into urban and regional studies, studies of human resources and social institutions, and studies in industrial organization. Programs of research on the structure of the economy and on the social and economic factors contributing to the quality of life and environment are in a broad way the new emphasis in Bureau activity. Questions concerning distribution of income and services within and among groups and economic sectors are now as much an integral part of the Bureau program as are the older or more traditional study areas including economic growth, national income, consumption, capital formation, business cycles, financial institutions and processes, and international economic relations. The new emphasis is on the quality and distribution of the fruits of economic activity as well as on factors determining the magnitude of the aggregate product.

In terms of method, much work continues in the aggregative macroeconomic style that has been characteristic of the Bureau through its first half century. In this 50th anniversary year, however, there is new emphasis on econometrics and measurement methods and on organization of electronic computer services in support of economic research. The Board has approved a "Proposal for the Creation of a Computer Research Utility in Economics and Management Service." This will be available to the relevant academic research community nationwide on a time-shared system operating through consoles.

The Bureau research covers a major part of the national economy. Some of the concepts and methodology have a broad relevance to agricultural economics and especially to that part dealing with economic growth and development of public policy. Colloquia topics in recognition of the 50th anniversary of the Bureau include, for example, The Business Cycle Today, Public Expenditures and Taxation, Finance and Money Markets, Industrial Organization, Human Capital, and Economic Growth. This report cannot offer a comprehensive review and, instead, concentrates mainly on some of the recent developments, particularly those that are believed to be of most interest to agricultural economists.

Urban Studies

Urban studies currently involve (1) a long-range effort to develop simulation models for explaining changes in urban spatial structure and (2) other urban problems such as employment problems in ghetto areas and effects of state tax transfers on local government. A land-use modeling study attempts to obtain improved and more complete econometric estimates of the determinants of location and other aspects (tenure, single family vs. apartment dwelling, and size of unit) of residential and industrial choice. Related to this is an attempt to develop "abstract" models that simulate the land and housing markets. These models are built by representing activities in a market setting involving in the case of housing a supply submodel, a demand allocation submodel, and a market or assignment submodel.

Residential location research attempts to extend and test empirically the basic theoretical framework of the classical residential location model. This is done first by identifying decision variables (income, race, sex of household head, number of employed people in the household, and stage in a family's life cycle or family size). The second step or extension of the theory is to allow decision makers to exercise their choices among locations that differ according to housing quality, land-use patterns, public services, social amenities, and the degree to which transportation links the various locations to each other and to places of employment. Another project in household location involves residential choices over time in terms of decision to move, tenure choice (ownership or rental), choice of neighborhoods, and housing characteristics.

Research on determinants of industrial location within metropolitan areas seeks to determine those

factors that are most important in the intrametropolitan location decisions of manufacturing establishments and then to use the quantitative information in these factors in construction of a prediction model of future locations. The research design centers attention on the importance of marginal components such as new firms, firms relocating within the area, firms going out of business or moving out of the area, and firms expanding their employment at present locations. Source information from the Dun and Bradstreet Corporation is being used in part of this reasearch. Data are available on an establishment basis, giving the following: specific location; year of formation; number of persons employed in the establishment and in the entire firm; codes indicating whether the location is a headquarters, branch, or subsidiary in a multibranch or multifirm corporation; and codes indicating classification of the establishment in terms of products produced, if any. The ultimate goal is not only to understand the dimensions of the location process but to determine which factors most strongly influence the intrametropolitan location decision and to quantify those decisions using behavioral models.

Research on ghetto employment problems is an example of the more recent attempts in the Bureau to undertake analysis of specific socially significant problem situations. This research as well as that on manpower policy generally rests quite directly on conventional marginal analysis. This takes history and current social institutions for granted and postulates the kinds of marginal adjustments an individual takes to function within the nexus of prevailing institutions. Two approaches are being compared. The "disadvantage" of the person in the ghetto is presumed to vary as the sum of a collection of individual "handicaps," such as relatively little education, lack of specific job or vocational training, or little information about job opportunities. Then presumably any marginal improvement of any relevant labor market characteristic will bring about an incremental improvement in the worker's labor market situation.

An alternative approach, on which emphasis is increasing, presumes that ghetto employment problems are an outgrowth of the prevailing institutions, that class distinctions and other retarding or differentiating situations among employees are maintained and manipulated in such a way as to maximize the advantage of those in control of the institutions. If this presumption is correct, it would lead to the general conclusion that labor market outcomes are determined primarily by those characteristics along which class distinctions are made and only secondarily by those characteristics to which economists conventionally attribute productivity. The research attempts to compare alternative sets of variables influencing labor market outcomes such as education and job experience, which are presumed to be related to productivity, with variables like race and sex, which are presumed to be more distantly related. Quantitative tests for discontinuities in the labor market are being attempted to determine if there is really a "secondary" labor market. The empirically derived definition of the secondary labor market may be used to help explain the effectiveness of the variables in influencing wages, occupational status, and other labor market outcomes. The results of this research can have important policy implications.

Regional Economic Studies

Differences among regions in economic and social conditions are the basis for various cross-sectional studies that are aimed at understanding these differences and their policy implications. Recent studies include differentials in hourly earnings in the United States, interregional migration flows, regional unemployment, and regional specialization in wheat production. Generally the attempt is to develop general conclusions and models of economic behavior. Although these studies are not a large part of the Bureau research, they may be of particular interest to agricultural economists because of the inferences for policy and because of our increasing involvement in community, rural, and human resource development.

Conflicting views concerning magnitudes of wage and income differentials among regions and the reasons for them are at the center of many controversies regarding the performance and equity of the economic system. Reduction of such differentials has been the stated purpose of many laws at federal, state, and local levels in recent years. Research in this area appropriately concentrates, therefore, on identifying the breadth and magnitude of such differentials and relates these to factors believed to be associated with them.

Current study on regional and city-size wage differentials has the following control variables: color, age, sex, education, occupation, and industry (classified by extent of unionization). It covers all nonfarm employed persons, including salaried and self-employed, and all nonfarm industries and occupations. Objectives include attempts to determine how large the differentials are after allowing for differences in city size, education, and other variables; to determine the interaction among such variables (for instance, is city size more important for whites or blacks, for females or males, etc.); and to provide a baseline against which differentials can be measured. The basic source of data is the one-in-a-thousand sample of the 1960 Census of Population. When data from the 1970 Census become available, tests may be run relating to the impact of the civil rights, education, and other legislation of the 1960's.

Studies of wage and income differentials, combined with other studies such as interregional migration flows, regional unemployment, and the like, offer suggestions for organizing research with which agricultural economists may be engaged in community and rural resource development. Wage and income

differentials among regions, areas, or communities, identified according to selected control variables, give a measure of under- and over-allocation of human resources in respect to other resources of a community, area, or region. Since moving or migration and other adjustments involve a cost, such data are one of the factors to be taken into account in development programs.

Human Resources and Social Institutions

One of the most significant expansions in the program of the Bureau is the new research on human resources and social institutions. Primary emphasis has been placed on developing a framework for human capital analysis under three separable program areas: (1) the relation between human capital and personal distribution of income in terms of the influence of schooling and post-schooling investment on the structure and time profile of earnings; (2) influence of human capital on consumption and labor-supply decisions; and (3) the influence of economic incentives on greater participation in illegal activities under the hypothesis that the frequency or type of illegal (criminal) behavior is responsive to relative gains and costs as visualized by potential participants.

During the past year, the Bureau has begun another series of studies on selected aspects of the relation between the stock of human capital, as reflected by educational attainment, and economic or social behavior. One set of studies deals with the influence of educational attainment on specific types of behavior which have measurable although not necessarily direct economic consequences. Another group of studies analyzes the economic returns to education, especially to higher education, corrected for the relation between "ability" and earnings. A number of different samples are being used to examine the relation between ability, education, and earnings. A model is being developed to explain changes in the stock of human capital over time, with particular emphasis on the role played by depreciation and post-schooling investment.

An interregional analysis of income distribution investigates the effect of human capital on the inequality and skewness of income or earnings. Findings of cross-sectional analyses for the United States, Canada, and the Netherlands, with comparisons among the United States, Canada, Puerto Rico, Mexico, Israel, and Great Britain, indicate (1) that schooling can explain a considerable proportion (often 15 to 20 percent) of the variation in income within a region; (2) that across areas either the rate of return or schooling inequality or both are positively correlated with the inequality of income; and (3) that there does not appear to be any systematic relation between the rate of return and the inequality of schooling.

A study on consumption, working time, and age is designed to explain how consumption varies with age to uncover the determinants of life cycle consumption patterns. The model emphasizes the dependence between life cycle consumption and life cycle labor-supply decisions. The demand for market goods varies with age. Variations in the price of time with age affect consumption in two ways: (1) A rise in the wage rate is a rise in the price of consumption time relative to market goods. When the wage rate is rising with age, individuals tend over time to substitute market goods for consumption time in their nonmarket production. (2) A rise in the wage rate implies a rise in the "shadow" price of household commodities. Changes in the derived demand for market goods depend, therefore, on changes in the wage rate with age.

The role of firms as suppliers of human capital assumes that firms are engaged in joint production, with human capital output as a by-product of production of market goods. Firms produce goods and services to sell, and they also produce human capital which is sometimes sold to employees. The cost of production is the foregone output necessary to produce the human capital, which appears in the form of increased knowledge about production processes and learning by experience, as well as outright training services such as those received by apprentices.

Some human capital has market value, and this can be sold to employees in the form of wage payments below opportunity costs as employees accumulate capital. Age-investment profiles and depreciation or obsolescence age-earnings profiles have implications for job training or other educational programs.

Some investments in human capital are entirely specific to the firm and have no alternative uses outside the firm. The problem in this case is to determine the firm's optimal accumulation of such capital. Specific capital output may take the form of additions to knowledge that shift the investing firm's production function without changing the production functions for other firms. Rational allocation of resources in time produces what appears to be secular improvements in total factor productivity that otherwise would be attributable to technical change or increasing returns to scale.

Studies in Industrial Organization

Studies in industrial organization involve four major areas: (1) the service industries, (2) economics of health, (3) diversification of industry, and (4) managerial incomes and stockholder returns.

The project on the service industries was begun in 1963 with the financial assistance of the Ford Foundation. A recent summary volume, *The Service Economy* [2], traces the transition of the United States from an industrial to a service economy and explains the growth of service employment, primarily in terms of developing a slow increase in output per man in the service sector. The service sector is compared with industry with respect to such factors as hourly earnings, behavior over the business cycle, industrial organization, and labor force char-

acteristics. Other publications deal with production and productivity and other aspects of the service economy.

Studies in economics of health, supported by grants from the Commonwealth Fund and the National Center for Health Service Research and Development, are designed to gain a better understanding of the factors affecting the demand for health and medical care, the productivity of medical care, and the socioeconomic determinants of health. A model of the demand for health assumes that consumers inherit an initial stock of health which depreciates over time and can be increased by gross investment. Gross investments in the stock of health are produced by medical care, a person's own time, diet, exercise, recreation, and other factors. Health is a consumption commodity directly affecting peoples' preference functions. Good health is a value in itself, sick days are a source of disutility, etc. Health is also an investment commodity determining the total amount of time available for market and nonmarket activities. Demand for health is a function of wealth, its relative "shadow price," and a monetary internal rate of return to an investment in health. Empirically, the study employes multiple regression analysis to estimate demand curves for health and derived demand curves for medical care. Whether health is measured by length of life or by healthy days, education has a positive and significant regression coefficient in the health-demand curve. An increase in age simultaneously reduces health and increases medical expenditures. A suggested continuous compounded rate of growth of the depreciation rate is 2.0 percent per year over the life cycle. The elasticity of substitution between present and future health is small but positive.

The study of the socioeconomic determinants of hospital use examines how extra-medical conditions of a hospitalized patient and institutional characteristics of the hospital where he is treated affect the amount and type of services the patient receives.

A study of the economics of accidents is built on formal model that identifies the factors affecting the incentives to invest resources in accident prevention or safety. It is hoped that this study will shed light on the current controversy in the automobile accident field between proponents of the fault system and advocates of replacing the system with self-insurance that approximates one of absolute liability.

Problems of Measurement

New attempts are underway to provide more satisfactory measurements of economic and social performance.[1] The existing income and product accounts, such as "Gross National Product" and the National Income Accounts, measure economic activity in the market, supplemented by imputed measurement of a few closely related nonmarket activities. At present and historically, however, a great deal is omitted that has to do with measurement of real income and investment. The accounts include as assets, for example, only tangible business assets and housing. These omissions become increasingly serious as emphasis is increased on studies of the structure of society and the performance of factors contributing to the quality of life and environment.

The current dissatisfaction with GNP accounts relates to specific areas: (1) the treatment or omission of nonmarket activities; (2) the way in which output is classified between consumption and investment; (3) the widespread use of input costs to measure the magnitude or value of output; and (4) the adequacy, or rather the inadequacy, of the accounts to measure output in terms of social and economic welfare. The problems of measurement relate to questions both of what is to be measured and of what analytical purposes are to be served.

In general terms, economic and social output is conceived as a flow of satisfaction or utilities derived from various combinations of capital assets, plus or minus changes in the value of the assets themselves. A suggested classification for the assets to be included has been presented [2, p. 14]: (1) tangible capital assets (equipment and structure); (2) intangible capital assets (knowledge); (3) human capital assets (skills and talents); (4) physical environmental assets; (5) sociopolitical environmental assets. Tangible assets include business assets, consumer assets divided into housing and durable, and government assets. Intangible assets are human capital and other resources applied to research and development which result in socially useful knowledge that is analytically distinct from the skills and talents of people who produced it. Human skills and talents include both innate ability and training. Physical environmental assets are natural resources, as traditionally viewed, plus results of man's development efforts (parks, forests, flood-control facilities, etc.) minus depreciation or deterioration. Assets in the sociopolitical category are meant to include such concepts as equity, security, freedom, social and economic mobility, privacy, and so on.

Although many problems are involved in this (or any other) classification, the argument is made that its use would result (1) in recognition of a much wider range of outputs as contributing to economic and social welfare and (2) in explicit recognition of changes in stocks over a wide range, thus giving more meaning to measures of net output since output partly consists of changes in stocks. Items to be brought into the accounts are large. Business firm expenditure on research and development, which would be added to gross investment, have been exceeding $20 billion a year. The total value of the stock of human skills and talents in aggregate probably would be much larger than stocks of business

[1] See especially, F. Thomas Juster, "On the Measurement of Economic and Social Performance," in [3, pp. 8–24]; see also [1] and [7].

capital. The consumer and government assets in the form of roads, parks, dams, appliances, furniture, etc., are also much larger than business-owned capital assets. Natural and environmental resources are of growing importance in our concerns for the quality of life. They are important in any measure of national wealth or gross national product; and more accurate measurement of resource appreciation, depletion, or despoliation is essential for guiding programs of production or investment in natural and environmental resources.

Implications for Agricultural Economics

Some of these dissatisfactions with current accounts and the problems involved in improving the measurements have peculiar implications for agricultural economists. These relate not only to traditional problems involved in attempting to measure income in agriculture and, to a lesser extent, factor productivity, but to broader problems now inherent in involvement in programs of community and human resource development. It is not clear, for example, where emphasis should be placed in program development between human and natural resources or between a labor-surplus low-income area versus one higher up in the income and product scale. More satisfactory measures of progress or improvement in welfare that we can apply to the local community are urgently needed. The problem of measurement is one requiring more comprehensive and theoretically meaningful treatment as a guide for more effective program development. Agricultural economists should welcome the attempts in National Bureau research to broaden and sharpen the measurement of income and product accounts, and it is hoped that ways may be found for contributing to the effort.

In a more positive view, other more specific conclusions may be drawn in regard to the trends in National Bureau research: (1) The new emphasis in regional economic studies in urban areas may help to identify a framework for working in community and human resource development programs in the nonmetropolitan sector. (2) The new emphasis in human resources and social institutions suggests ways of studying the effectiveness of education and other institutions or programs designed to improve the human resource. (3) The studies in industrial organization, especially those dealing with the service industries, suggest research for improving the environmental services of the nonmetropolitan community. Research by agricultural economists and rural sociologists on development of improved medical facilities and services in nonmetropolitan areas now has a counterpart in the work on economics of health and health services. An interaction may be beneficial. (5) The Bureau emphasis on regional research and the service industries suggests a framework for research in intraregional and interregional differences in farm income and in various aspects of farm-nonfarm mobility, employment, and earnings.

As the work and career agenda of agricultural economists expand to include the total nonmetropolitan economy, including farm and nonfarm economies, the relation of these economies to the national economy becomes increasingly significant. The new challenge to agricultural economists is (1) to a broadening of their research outlook and (2) to a more empirically accurate research output in a general macroeconomic as well as microeconomic context.

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MICHIGAN STATE'S KELLOGG FARMERS STUDY PROGRAM: A PROGRESS REPORT

It is generally true that rural people are not adequately prepared to participate effectively in public affairs. In general, the rural population does not have easy access to schools that offer high-quality courses in social studies, government, economics, speech, composition. literature, and history. Today more rural people are acquiring some college-level education in community colleges, short-course programs, or regular university curricula. While these experiences may be broadening, they often deal almost entirely with technical subjects.

Recognizing this shortcoming among young Michi-

gan farm businessmen, Michigan State University and the Cooperative Extension Service, with the financial aid of the W. K. Kellogg Foundation, developed a continuing adult education program. This program, the Kellogg Farmers Study Program, has been in operation since 1965 on an experimental basis. The rationale for the Michigan State project was the demonstrated fact that successful Michigan farmers with sound management talent, utilizing the latest in scientific and technical know-how, were lacking in the liberal arts and social science knowledge and understanding necessary to effective participation in today's complex urbanized and industrialized society. The stated objectives of this experimental program have been:

(1) to provide an understanding of the social, economic, and political framework within which modern agriculture functions as an integral part of an urbanized industrial society;

(2) to use this framework in analyzing state, national, and international problems, both agricultural and nonagricultural; and

(3) to develop the creativity and analytical ability of the individual; to broaden his cultural and social perspective; and to provide him with tools and experience in the art of communications so that he may assume more effective and responsible roles of leadership and informed followership in the many "communities" in which he is a citizen.

To accomplish these objectives, groups of 30 farmers have been chosen each fall since 1965 to participate in a three-year program. Selection for the program is through nomination and application and has been based on four criteria: (1) commitment to agriculture as a means of livelihood; (2) membership in the 25–35 year age group; (3) possession of potential leadership ability; and (4) a demonstrated interest in public and community affairs. From the beginning, selection as a Kellogg Farmer has been a prestigious event for participants and their communities.

The program format includes nine weeks of study institutes on the MSU campus; three two-day summer institutes with wives participating; and state, national, and international traveling seminars. The campus-based institutes have provided approximately 370 hours of classroom instruction. University, government, and industry representatives have covered a broad array of subject matter areas, including political science, economics, sociology, communications, education, history, philosophy, and the arts. Wives of the participants are formally involved in several aspects of the program.

The accompanying curriculum is an example of the hours devoted to each general topic and of the year-to-year transitional development. During the State Traveling Seminar, participants spend a day with their state legislators discussing issues of mutual interest and observing a legislator's typical day's duties. The participants also meet with representatives of the various departments in the executive branch of state government, with representatives from the judicial branch, and with lobbyists to gain an understanding of their functions. Another part of the State Traveling Seminar is a trip to inner-city Detroit to talk with low-income people and to observe various social institutions operating to effect change. At the end of the second year, a two-week National Traveling Seminar takes participants to Washington, D. C., where they meet with officials in the USDA and HEW. They meet with Supreme Court judges, their congressmen, and lobbyist groups. They also travel to southern and western states to observe social institutions operating in both urban and rural settings and different kinds of agriculture.

The third year of the program is devoted to preparation for a four–five week International Traveling Seminar. This involves examining the geography, religions, history, social, political, and economic systems of these countries, as well as U. S. foreign policy and foreign policy of other countries.

During the campus-based institutes, participants meet informally with university professors, industry representatives, and government officials, with whom they discuss freely many problems, issues, and ideas. They also attend concerts, plays, and other fine arts performances scheduled at the university.

At the end of the five years of program operation, the dropout rate has been minimal. Of the 90 farmers starting in Groups I, II, and III, 85 completed the three-year program. Groups IV and V are presently intact, with their full complement of 30 farmers each. The attendance rate at institutes and travel seminars has been extremely high. Group I participants contributed their time away from home and travel expenses to the campus institutes. Each successive group has contributed more toward the program budget. Group IV is paying $150 per year tuition and, in addition, will pay about 60 percent of the cost of the national and international travel. Group V, selected in the fall of 1969, pays $400 per year tuition and will also share in the cost of the international travel. It appears that participants will make considerable personal sacrifice to take part in this type of adult education program.

We have many individual incidents and impressions from which generalizations concerning success can be drawn. An increase in the level of oral communication skills is strongly in evidence as the program progresses. At least one participant in each group during the first practice session in the communications block chokes up and cannot utter a sound. With patience and encouragement from other participants one such person was rated later by his communications instructor as one of the best speakers of the session. After spending a day in the Detroit ghetto, one Kellogg Farmer commented retrospectively, "That's the first time I ever shook hands with a Negro." Another participant subse-

quently was moved to take his wife and family and some neighbors on his own tour of the ghetto. Five of the 20-member Farm Bureau State Resolutions Committee are Kellogg Farmers. They are among the youngest members of that board and have been influential in the State Farm Bureau's stand on several policy issues as exhibited by last year's resolution on farm labor:

> We are encouraged by the current arousing of social conscience and public awareness with regard to special problems related to seasonal farm workers. . . Even with the recent gains farm employers have provided for seasonal employees there are still problems inherent in migrating from state to state each year, particularly for a group with a low general educational level and when a language barrier is sometimes present. In light of these facts: (1) We commend leaders in government and civic organizations for realizing the presence of these special problems. (2) We encourage members of the legislature and leaders in agencies of government to be informed of the true agricultural labor situation so that understanding, reason, and knowledge of the farm labor system and the agricultural situation will guide the development of legislation and implementation of programs dealing with farming and farm labor. (3) We caution these leaders against reactionary approaches to emotion-packed allegations by certain pressure groups that would lead to the establishment of costly and unwise programs that would be of little value to seasonal farm workers while causing unnecessary hardships on farm families. (4) We encourage state and federal regulatory agencies to work toward simplified interstate recruitment procedures so that workers will be encouraged to have employment arranged before they leave their home states.[1]

Participants have also exhibited a propensity to include in their leadership activities a more political orientation in the local community, state, and international affairs. This year a Kellogg Farmer was elected to the state legislature.

Finally, one Kellogg Farmer decided, after his exposure in the program, to continue his formal education beyond high school. So, in addition to his full-time farming occupation and his participation in the Kellogg program, he is enrolled in the degree program at a nearby community college.

An MSU political scientist, after a block of Kellogg seminars, reported his experience to the faculty and graduate students of his department. His major point was that the academic snobbery exhibited by some of his colleagues in their feeling that only the academician is well-informed and can interpret current events and issues was totally false, based upon his contact with the Kellogg Farmers. He also made the plea that his colleagues should seek out opportunities for similar types of experiences in order that they might better understand and appreciate the level of sophistication people in the "real world" have concerning issues and events of the modern world.

Another MSU professor, much in demand as a speaker, indicated he was drastically cutting his public appearance schedule but that he would always be available to seminars with Kellogg Farmer groups, since they were interested and interesting and were able to present a challenge to him and his ideas during the interchange. He recently asked that the modest honorarium offered him by the program be donated to one of the groups for the continuation of their program after the formal three years were ended.

One group, during the National Traveling Seminar, visited a medium-sized rural town in the South. They spent a day and an evening discussing problems of race, school integration, poverty, employment, and public services faced by the town. They talked with concerned citizens, the students, the poor, and the old line, powerful, white establishment group. Their presence contributed to a better understanding among the citizens of the town, as evidenced by the following except from a letter written to the Kellogg Program staff by one of the town's citizens who helped arrange for the visit.

> You cannot imagine the glowing comments I have received about your farmers from all people in **** and here in ****. They all felt it was such an exceptional group of young men. . . Also, you cannot imagine how much good you all did in all areas; for example, in the case of Mrs. ****, her own boss and coworkers had never really seen her as we saw her that night. Because of this she has been invited to participate in district meetings and has been given much more recognition.
>
> In the case of the families visited, many of these and the leaders were made aware of needs and resources that could be tapped in the community, and they have also been helped.

Finally, each Kellogg Farmer group as it has completed the formal three years of the program has decided to meet at least twice a year for a substantive program to remain current on issues and subjects. They plan their own programs and pay the full costs of their meetings. One such program recently included sessions with the Democratic majority leader in the Michigan Senate for a review of current and pending legislation. Also, they held a seminar with a prominent Michigan civil rights leader. Thus, we can conclude that the program has stimulated an interest in current issues and a desire on the part of participants for continued renewal and updating in public affairs. In addition, recognized agricultural and political leaders in Michigan have indicated favorable appraisal of the program because of the increased participation and sense of mature responsibility they find in the program participants.

The MSU Department of Agricultural Economics

[1] 1970 Policies, Michigan Farm Bureau, adopted by the Board of Delegates of the Michigan Farm Bureau 50th Annual Meeting, East Lansing, Nov. 1969.

and Cooperative Extension Service have become committed to a continuing leadership development effort through the successful application of the experimental Kellogg Farmers Study Program. Accordingly, support for an expanded adult education program in public decision making on a continuing basis is being provided. During the next two years the experiment is being expanded in terms of program levels and intensity, number and types of participants. The campus-based program will be retained as a two-year effort; the very costly internationally-focused third year will be discontinued. Less intensive regional three-year programs are being developed throughout the state. They are focused on local and state public decision making and leadership development. This effort involves more people and will provide a reserve of interested persons from whom participants for the more intense campus-based program can be selected.

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Appendix. Kellogg Farmer Curriculum

There is no fixed curriculum for the Kellogg program, although each class studies essentially the same subjects in corresponding phases of the course. The following schedule is typical of the study program. In addition to these courses there are about 100 hours of summer and special institutes, special problems, and outside reading assignments.

First Year	*Hours*
Elements of the pricing system	7
Banking and the Federal Reserve System	7
State and local government	12
American government	5½
Reading more effectively	5
Individual and group communications	22
America as a mass society	5
Problems of the inner city	4
Poverty and its implications	5½
Prospects of farm organizations	1
Ethics and morality in society	6
Natural resources	9
Understanding ballet	1½
National Ballet of Canada—MSU auditorium	2
Second Year	*Hours*
Labor, structure and characteristics	8
U.S. money and fiscal policies	4½
Sources and uses of agricultural data	2
Michigan property taxes—reform or repeal	2
Case studies: milk and cherry marketing	4
Marketing cost studies	15
U.S. Agricultural policy	5
Decision making for producer organizations	3
The Federal executive branch	5
Comparative political systems	5
Attitudes and values in society	5
Large group communications	14
Cultural expressions in art	2
The challenge of world hunger	3
Visits with leaders of farm organizations	10
A geographer's commentary on America	5
Third Year	*Hours*
Trade and economic development	6½
The European Economic Community	10
U.S. and European foreign policies	6½
The language problem	3
World religions	10½
Organizing an effective meeting	1½
Communism as a religious force	1½
Orientation on Europe including farm organizations	6½
Orientation on South America, Asia and Africa	20½
Federal farm programs and history	3
Taking pictures	1
Sensitivity training	3½
Shakespearean theatre	2
"Romeo and Juliet"—MSU auditorium	2

REORGANIZING SOCIAL SCIENCE RESEARCH IN AGRICULTURE*

For a number of years there have been low-key rumblings about the kind of research being done and its potential applicability and suitability both for the short and long run. In recent years these rumblings have become more ominous and widespread among the lay public as well as among professionals [1, 2]. Society is no longer willing to wait for the traditional slow pace of research to find answers to social problems.

Although questions are being raised about the relevance and quantity of research in all sciences, the remarks in this paper will be confined largely to the social sciences as supported by funding through the agricultural colleges; that is, primarily agricultural economics, rural sociology, rural community development, economics of environmental control, and development of natural and human resources in rural areas. However, some of the alternate recommendations given here could be transferred to public-supported research related to other scientific disciplines.

Clearly, we need some sort of aggregate utility function that can be read with precision. Priorities and a relative allocation of resources could be determined by such a function. Priority rankings might persist with changes in resource levels available for research. However, the relative magnitude of research funds and relative number of research man-years allocated to different priorities might change substantially at different total levels of resource availability.

* The author was stimulated to prepare this paper by Carroll Bottum. He also appreciates the helpful comments by Harold F. Breimyer, R. James Hildreth, and others.

Approaches to Research

Let us look at current approaches to research in academic agricultural social sciences. Little inter-researcher coordination or interdisciplinary coordination are employed. Much research work is conceived and carried out by the individual (in association with clerk typists, graduate students, other assistants, and computers) and then individually reported to an anonymous audience—often with little or no reaction expected. Frequently, as far as the researcher knows, this is the extent to which his research is used. Researchers seldom give seminars or workshops based on their research results to *potential users*.

Most researchers at educational institutions write for the edification of their professional colleagues rather than to a wider audience who might make greater use of their research. The university system tends to demand and reward this kind of performance. Apparently publication in the popular press, which has the greatest circulation, is rated the lowest; while publication in the select professional journals, which have a small circulation, is rated the highest. Also, articles written by a single author have a higher rating than those written by several persons. Thus, the kind of individual research that can be deciphered only by the researcher's more sophisticated peers is usually ranked the highest.

In normal life conception cannot take place in a sterile environment. Yet researchers often seem to conceive research problems within the "isolated cocoon" of the educational institution (the ivory tower, if you will), with little or no consultation involving Extension people or others who might have some feel for real-world problems and priorities.

Few project proposals are turned down, although they may be returned for rewording or "reorientation." The researcher complies, and the project is approved in due time. The researcher then proceeds to work on his problem in the way he planned and at his own pace. The work, individually conceived and produced, has little or no supervision because supervision would be considered an encroachment on academic freedom and also insulting by the "eminently well-qualified" researcher.

We have all come to accept this modus operandi, philosophizing that significant discoveries were made on projects only remotely related to the project's objective. Besides, creating a prescription for great minds to follow toward discovery is impossible, isn't it? Some assume that research guidance by the "invisible hand" is sufficient [3].

The time schedule for a typical research project might be as follows: submission of proposal, 30 days; proposal review through all channels, 60 days; normal revisions 30 days; resubmission and approval, 90 days; research development, 90 days; gathering data, 180 days; computer analysis of data 180 days; overall analysis of results, 180 days; writing a research paper, 30 days; journal review, 90 days; normal revisions, 30 days; final acceptance for publication, 60 days; time lag between acceptance and publication, 180 days. This is a total of 1,230 days from submission to publication, or about three and one-half years. Additional time usually elapses before a potential user discovers the journal article or before it is presented in form for potential users. By this time, assuming that the research initially involved an important problem, it may have already been solved some other way.

Other factors are involved in the lag between initiating research and the emergence of findings. Most research workers are not exclusively engaged in research, nor do they work on only one project. They also teach, serve on committees, consult, and advise students. Contrary to a popular misconception among graduate students that a major professor is a leech on the student's creativity and productivity, most researchers could accomplish more research with assistantship money allocated to good clerical-typists.

The academic community has yet to recognize a basic economic principle—that there are economies in the division of labor. The main counterargument is that research and student education are at least complementary, if not symbiotic. Graduate students must be trained. Their research work is an apprenticeship, a kind of on-the-job training; and any research production from them is a positive product. Another argument often made is that researchers (usually part-time researchers, part-time teachers) are better teachers because they use their research to bring important developments to students. There would be a time lag for students of several years if teachers depended entirely upon textbooks and published research.

Although the picture of research in our large educational institutions may not be this dismal, a devil's advocate could project an even worse picture. Much of this research inefficiency and lack of specific problem orientation based on social priorities grows out of the existing organization for research.

Alternate Ways of Organizing Research

Research could be organized and stimulated in several different ways [4]:

(1) *Reorganizing regional research.* The directors the experiment stations in the North Central area have responded to social judgments about the relevance of current research by eliminating the host of regional committees relating mainly to commercial agriculture. Three committees—one on commercial agriculture, a second on natural resource development, and a third on community and human resource development—are the new structure. I believe this restructuring, with only one committee oriented to commercial agriculture, is an attempt at the regional level to reallocate resources or at least to recognize the direction that the Congress (with the power of the purse) wants to go.

However, most of the research funds in land-grant colleges are not in regional research. Most of the money still goes to individual scientists who are not sensitive to a reorientation of priorities.

(2) *Centers of excellence.* The experiment station directors of the North Central region recently proposed another alternative for the organization of regional research, that of establishing "centers of excellence" for specific problem areas.[1] Under this plan, an experiment station would have the broad responsibility for developing and supervising all regional research under its designated "umbrella" program area. Another land-grant university desiring to work in this area would have to look to the designated "center of excellence" for direction and approval of proposed research work. If approved and implemented, this reorganization of regional research could provide the infrastructure needed for better coordination and control and should give stimulus and direction. The directors recommended Nebraska as the program center for Foods and Human Nutrition; Illinois, for Environmental Effects on Crop Production; and Minnesota, for Natural Resource Development, Management, and Use. Other program-center designations would likely follow approval of these recommendations. Although this change in structure would apply only to regional research, such centers could encompass most research funding.

Drawbacks to this plan include difficulties in shifting program emphasis with changes in demand for research in various topic areas. Unless very broadly conceived so that programs could be shifted as priorities change, such centers might be inflexible, because administrative structures tend to persist long after their usefulness is past. And such a structure could also stifle the development of a program at a university that is not the "center," even when the "non-center" university might in fact have substantial competence in that problem area.

Let us assume, for example, that the University of Missouri becomes the center for Community and Human Resource Development. Many of the better researchers in the region interested in that area would gravitate toward the University of Missouri. Graduate students interested in this topic area would likely go there to work on their final degrees. Other professors working in this area, but not on the Missouri staff, might go there during sabbatical leaves. Most of the research done at Missouri on community development should be generally applicable to the entire North Central region.

If a particular state wants to do additional research, perhaps locally oriented, this could be handled in one of several ways:

[1] As initially, proposed, the "centers of excellence" idea was turned down by the Committee of Nine in Washington. However, the President's current budget contains a proposal for a center for community and human resource development in each of the five administrative regions.

(1) Their own research worker or team might go to Missouri for a short period—say, 6 months—to carry out the desired research where the library and expert research counseling in this problem area would be readily available. Also, by physically going to the "center of excellence," the local state researcher would be away from his peripheral committee and teaching duties and could concentrate on the required research work.

(2) The state could contract with the center of excellence for specific research.

(3) The state might pay a researcher from the center of excellence to come there for a specific project.

When statewide extension work in community development is to be initiated, the state could send its Extension team to Missouri for a concentrated short course of perhaps 30 days on a specific phase.

(3) *Contracting with the experiment station for research.* A third method of organizing research would be by contract. This might have less effect on the present administrative structure. Suppose, for example, that 60 percent of all research funds is allocated to the Cooperative Extension Service instead of the experiment station, but with the proviso that this money be used to contract for the research needed to solve the problems confronted. (I suggest 60 percent in keeping with the customary land-grant philosophy of having a majority of research oriented toward practical problems and service work. The remaining 40 percent might be retained by the experiment station for basic research.)

Let the state extension service articulate the specific research demand, allocating the funds according to its estimate of priorities and contracting for the problem-oriented research with its own university research staff. If other universities, such as the centers of excellence, have greater expertise in the problem area, a limited proportion of the funds might be used to contract with these centers.

(4) *Contracting with private research groups.* A fourth method of mobilizing research while applying the division of labor would be to contract with research institutes or corporate research divisions. Doing this would allow universities to concentrate their efforts again on teaching—their historical prime mission. A research-education relationship could be maintained by making arrangements for graduate students to do their research apprenticeships in the research institutes. Also, university teachers might take their sabbatical leaves at one of the research institutes. University staff members who prefer research work to teaching could seek employment with research institutes, government agencies, or in the private sector. However, joint appointments between a research institute and a university would be self-defeating.

(5) *Joint extension-experiment station appointments.* The fifth alternative for generating and carrying out research, one which might disturb present

organizational structure the least, would be to encourage more joint appointments between extension and research, rather than teaching and research or research alone [5]. The assumption here is that the extension worker is better able to recognize the problem areas that need research, to discern the needs that have higher priority, and to allocate his own research time accordingly. On a 50–50 appointment, his time might be utilized best by spending half a year on full-time extension and half a year on full-time research, rather than being half-time in each role the year around. Also, he might be assigned graduate research assistants.

Describing the Demand and Supplying the Product

In almost no other activity has the demand for the service been so frequently generated by the producer as in research. Surely the individual research worker, as a producer, should not be the one to specify the demand for research.

In the last three alternatives for mobilizing research, the setting of priorities, the general orientation, and the decision about the amount of research effort would be taken out of the hands of the individual research worker and would place those research-demand criteria closer to the hands of the ultimate consumer by putting the decision in the hands of the extension service.

Time schedules for research are also an essential part of the demand. Deadlines should be specified for exchange and critique of proposals by each of the researchers involved. Similar deadlines should be specified for the beginning and end of different phases of the research, preparation, and review of results, and their dissemination. On each deadline date the research group might meet in conference or have a conference telephone call, if they are located at different stations, to check on progress, to change orientation where needed, and to reinforce each other's continued interest in meeting specified project goals. After results have been analyzed and reported, researchers should still be responsible for interpreting results, if needed, to extension workers. On some routine basis researchers should also communicate the insights gained and additional findings not usually published. After the research is completed researchers should participate in or conduct training workshops for extension workers when such training is needed.

Since publication credit is important to researchers in terms of salary and promotion, definite arrangements should be made at the outset to publish the results, either in joint publications at varying stages during the whole research program or as a series of seminar or conference papers. Certainly a clear understanding between the cooperating researchers about proprietary rights in a publication is needed at the beginning, so that current and follow-up research and communication to others are not jeopardized.

Other avenues for stimulating and organizing research also need to be explored. It seems feasible to have contract research sponsored by users or groups of users themselves or to have cooperative research that a user group helps to support when the research is of high priority for society and will be made available to all of society. Contract research probably comes closer to having a specified demand for researchers than any kind of research except direct consulting.

If our discipline is to continue making positive contributions to society, these problems need solutions. Some solutions have been suggested here; still others may be needed. But after laying out the avenues of possible change, there is some urgency about making decisions on which avenue to take. A decision made now with imperfect knowledge may be better than a decision made later with perfect knowledge about all possible alternatives.

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AAEA EMPLOYMENT SERVICE

Since its inception a few years ago the AAEA employment service has continued to expand and has become a major activity at annual meetings. In 1970 the president suggested that the service should not be operated when it would conflict with general sessions. For those seeking employment, strong economic interest tends to take precedence over most other affairs.

Rumors circulate at meetings and within the profession concerning applications and vacancies, the

Table 1. AAEA employment service information summary, 1970

Total applicants	256
Graduate student applicants	163
Professional applicants	93
Requests for confidential treatment	11
Bachelor's degree applicants	1
Master's degree applicants	53
Ph.D.'s or Ph.D. candidates	202

ratio of jobs to seekers, salaries, etc. This note may allay some misconceptions as well as provide information that we hope may bring improvements to our most personally important market. While the formal employment service is only the visible tip of the market for agricultural economists, it can or should be an important aspect for "freeing" a market that operates imperfectly. Making data on the employment service available should improve knowledge of the market and thereby improve its operation.

1970 Applicant Data

A total of 256 individuals seeking jobs registered with the employment service in 1970, an increase of 45 from 1969 (Table 1). Of these, 163 were graduate students while 93 were in the professional category, i.e., basically those already holding jobs but seeking a change in employment. The latter service was started in 1969 at Kentucky and can be confidential. However, only 11, about one-fourth as many as in 1969, elected to remain anonymous, although the number of applicants in the professional category increased from 48 to 93. Most applicants held doctorates or were doctoral candidates (202), while one had a B.S. degree and 53 held the M.S. or M.A. degree or were working toward such degrees. Of the graduate students, 138 of 163 applicants had not completed their degrees, while 9 of the 93 professional applicants also were degree candidates.

Applicants indicated their area(s) of specialization, with from one to several per candidate (76 listed only one area); however, no more than three were used to classify applicants in the directory prepared for employer use in 1970. These are summarized in Table 2. The classification used by Hitzhusen [1, p. 137] was used for the directory, except that the "food and nutrition" category was eliminated and "general economic theory" was made a catchall for "theory, general agricultural economics, and other" areas. The primary or first choice area breakdown was somewhat different from that reported by Hitzhusen but exhibited a similar general pattern and a continuation of some of the trends of recent years. The "theory and other" category was considerably larger for the applicants than in the general breakdown. In addition to several categories not included in the usual agricultural economics subareas (e.g., business analyst), many of those in the "other" category were persons desiring work in economics departments of smaller schools. Many who go into such jobs later drop their affiliation with agricultural economics.

"Marketing" and "farm management and production economics" remained large categories but were relatively smaller than in the 1966 classification. "Resource and regional economics" (Hitzhusen's "land and water economics, conservation, and development"), at almost double its 1966 employment proportion, ranked with "marketing and farm management-production economics." This appears to correspond to recent changes in societal goals, assuming that interest in resources is related to environmental problems. International area applicants were about the same percentage as employment in 1966. The proportion of applicants who gave as their main interest area one of the quantitative fields (statistics, econometrics, etc.) was considerably higher than the employment proportions for 1956, 1961, and 1966, as reported by Hitzhusen.

Proportions of graduate students and professionals listing the various areas of specialization generally followed similar patterns except for "farm management-production economics" and "theory and other." The proportion of graduate student applications in "farm management-production economics" was about double the professionals, 21 percent versus

Table 2. Areas of specialization by AAEA employment service applicants, 1970

Specialization	Total applicants		Graduate students		Professionals	
	number	*percent*	*number*	*percent*	*number*	*percent*
Marketing	55	21.5	34	20.9	21	22.5
Farm management and production economics	46	18.0	35	2.15	11	11.8
Resource and regional development	49	19.1	31	19.0	18	19.4
Foreign trade and development	26	10.2	18	11.0	8	8.6
Agricultural policy	6	2.3	4	2.5	2	2.2
Quantitative areas	20	7.8	13	8.0	7	7.5
Finance and credit	12	4.7	9	5.5	3	3.2
Agricultural price	7	2.7	3	1.8	4	4.3
Theory, general agricultural economics, and other	35	13.7	16	9.8	19	20.4
Total	256	100.0	163	100.0	93	100.0

Table 3. Employers and vacancies listed with AAEA employment service, 1970

Employer category	Number of employers interviewing	Percent	Vacancies listed	Percent
Universities and colleges	39	56.5	67	57.3
Government agencies	15	21.7	31	26.5
Banks	5	7.3	7	6.0
International agencies	3	4.3	5	4.3
Cooperative organizations	3	4.3	3	2.6
Private industry	3	4.3	3	2.6
Consulting agencies	1	1.5	1	0.8
Total	69	100	117	100

12 percent; while professionals were more than twice as important relatively in the "theory and other" category.

Over 70 percent of graduate students reporting an occupational preference listed academic institutions as their choice.[1] About 17 percent listed business first and 8 percent preferred governmental employment.[2] Along this same line, 53 percent of the graduate students indicated that teaching was the most preferred type of work while 24 percent favored research. Over 70 percent of both groups listed both teaching and research within their top three preferences. Only 10 persons in both groups said that extension was the most preferred type of work, although 35 listed it among their top three preferences.

[1] Although organization preferences were indicated on the professional form, they were not in order of greatest preferences and thus cannot be compared directly with those of the graduate students. However, about 73 percent of the professionals gave academic institutions as one of their choices.

[2] Although only a relatively small percentage gave business as first preference, it was interesting to note that one industrial employer had requests for interviews from over 100 applicants on the first day of the service.

Table 4. Job openings by area of specialization, AAEA employment service, 1970

Specialization	Number of openings	Percent
Marketing	25	21.4
Farm management	20	17.1
Quantitative methods	17	14.5
Public policy	15	12.8
Production economics	11	9.4
General agricultural economics	10	8.6
Economic development	8	6.8
Finance	8	6.8
Business management	3	2.6
Total	117	100

Job Vacancies

The 117 job vacancies listed by 69 employers with the employment service in 1970[3] represent a decrease of 32 from 1969 and reflect the generally slower employment market that characterized other disciplines and the economy as a whole. Of the total, 57 percent were vacancies at universities or colleges and 26 percent were in governmental agencies. These two employer categories were over four-fifths of all vacancies listed. The balance of the vacancies were rather evenly distributed among international agencies, cooperative organizations, private industry, banks, and consulting firms, as shown in Table 3. The majority of job openings required Ph.D.-level training, although a significant number of banks and businesses indicated that an M.S. degree would suffice.

Position openings in universities and colleges were divided about equally between teaching-research

[3] Several employers registered with the employment service without listing any job vacancies and were later seen interviewing. We recommend termination of the practice of issuing courtesy passes and refusal of access to the applicant binders to anyone who had not filed at least one vacancy with the service.

Table 5. Use of the AAEA employment service, 1961–70

Meeting	Type of employer: University	Government	Industry	Total	Total job vacancies	Total available for employment
1961 (Colorado)	—	—	—	44	60	87
1962 (Connecticut)	—	—	—	46	117	81
1963 (Minnesota)	—	—	—	56	158	93
1964 (Purdue)	—	—	—	—	135	115
1965 (Oklahoma)	—	—	—	106	145	192
1966 (Maryland)	61	50	16	127	217	138
1967 (Guelph)	48	28	14	90	202	160
1968 (Montana)	44	18	8	70	133	154
1969 (Kentucky)	44	18	14	76	149	211
1970 (Missouri)	39	15	15	69	117	256

and positions with at least one-half time extension. As shown in Table 4, marketing outranked other areas of specialization in the job descriptions that accompanied vacancies but was closely followed by farm management, quantitative methods, and public policy.

In general the employment market for agricultural economists was off in 1970 but nevertheless showed some firmness in comparison with other academic disciplines.

Concluding Comment

The primary market for agricultural economists, as for most of academia, operates on an interpersonal basis and is very imperfect. There is no open market, and little price information is available except on an oral basis. With the heterogeneous product and without standard grades, price information becomes difficult to interpret. The main function of the AAEA employment service is to provide the opportunity for a freer and broader exchange of information between the direct parties. This makes possible initial contacts beyond the scope of advisers, acquaintances, friends, and colleagues. To the extent that the service is utilized some of the knowledge imperfections are lessened and a freer flow of talents is enhanced. Actual use of the service for 1961–1970 is reported in Table 5.

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ESTIMATES OF INCOME EFFECTS FROM WATER TRANSFERS: A CRITICAL EVALUATION OF THE HARTMAN-SEASTONE ESTIMATES FOR IMPERIAL COUNTY, CALIFORNIA

The recent book by Hartman and Seastone [1] provides a useful theoretical framework for evaluating the economic efficiency of water transfers between alternative uses in the arid West.[1] However, we take issue with the authors' empirical estimate of the value of an acre-foot of water, transferred out of Imperial County, California, presented as an illustration of empirical implementation of their theoretical model [1, ch. 8].

The authors say in the first sentence of the chapter that the estimates to be presented will give "some" empirical content to the theoretical model developed in chapter 7. At two subsequent places in the chapter (pp. 105 and 106) they caution almost parenthetically that because the empirical implementation presented is meant to be illustrative only, quantifications of some of the elements in their model are "chosen somewhat arbitrarily and without justification." Thus, by implication, they argue that the particular value of the estimate they derive is not important. We disagree. Our experience in publishing the results of water resources research has taught us that this is one area of research that is read avidly by the public (or, more accurately perhaps, by its elected and appointed water policy leaders). Because of the popularity of water resource development among both state and federal agencies and local water users, particularly irrigators, estimates of the value of an acre-foot of water, *especially if these estimates are of a large magnitude*, are quoted and requoted for consumption by the voting public.

Their use of "capitalized value" to portray the value of diverted water is an unfortunate choice. It is customary in the West to refer to the value (cost or price) of water in terms of its value (or cost) per acre-foot per unit of time (usually per year). The careless, biased, or unsophisticated reader will interpret the value of transferred water at $295 per acre-foot, as derived in this chapter, as a very "high" value, in spite of the fact that it is always referred to as the "capitalized" value of water. In fact, $295 per acre-foot is not a very "high" *capitalized* value of water as such water costs go in the Southwest for newly developed supplies of water for water-short areas. Inasmuch as transfer of an Imperial Valley water *right* is a transfer in perpetuity of a right to receive a perpetual *flow* of water and inasmuch as the discount rate used in the analysis to derive the capitalized value is 5 percent, the equivalent *annual* value per acre-foot of flow is ($295 $\times$ .05), or $14.75 per acre-foot per year. A figure of the latter magnitude of the "value of out-transferred water" would produce much less mischief than would the former in interpretation by the lay public or a biased edite.

Unfortunately, the authors themselves abet just such mischievous interpretation, falling into their own trap by explicitly drawing a policy conclusion from their value estimate (p. 108): "The order of magnitude of the above estimates [$295 per acre-

[1] A general review by Kelso of this book appears in this issue of the Journal.

foot] calls into question the desirability of large block withdrawals of water from developed agricultural areas, as some have proposed."[2]

Quite apart from the possible mischief stemming from the *form* (capitalized value) of the estimate chosen by the authors, the empirical estimates of their chapter warrant no such statement as to the desirability of the water transfer.

The analysis focuses narrowly and only on economic interdependency within California resulting from the disappearance of food and feed grains and forages from within the Imperial Valley. In terms of their own theoretical model of chapter 7, this constitutes only area A (the water-exporting area) and part of the area C ("rest of the world") effects. Similar analyses covering at least area B (the water-receiving area) and, to be complete, the rest of the area C effects as well are not included, nor even alluded to. Regardless of the magnitude of any derived value of out-transferred water in the area of its origin, no policy implications of any sort can be drawn from it (except maybe how much the selling area should be "paid" for it to cover its "losses"); policy conclusions concerning a transfer are possible *only* if area B and C effects are also evaluated. Not only was no such analysis made of these area effects, what is more critical, the authors did not even mention in chapter 8 that such empirical analyses would be necessary before policy implications concerning water transfer out of the Valley could be drawn.

Immediately following the above quote relating to policy implications, the authors added [1, p. 108], "It seems doubtful that any manipulation of data or assumptions would radically alter the order of magnitude of the above estimates."

We turn now to those questionable assumptions and to those omissions from their analysis that call into question the validity of this second statement. We begin by recalculating the authors' own estimates, retaining their key assumptions but modifying several points in their data interpretations: (1) their unexplained exclusion of all taxes from household income which, following their explanation of coefficient derivation [p. 97], we restore to the profit coefficients and thus raise their estimate of water value; (2) their use of water coefficients pertaining to California as a whole (obtained from [5]), for which we substitute those derived by us for Arizona [4] (which more nearly reflect the arid but irrigated conditions of the Imperial Valley) and thus lower their estimated water value; (3) their unexplained elimination [1, p. 105, Table 10] of all indirect profits in the feed and forage sector (which implies they are 100 percent recoverable), for which we substitute their estimate [1, p. 106] of 48 percent nonrecoverability and thus raise their value estimate; and (4) their unexplained implied assumption that 48 percent of indirect profits in the "other" sectors [1, p. 105, Table 19] is unrecoverable which is their estimate of unrecoverability in the feed-forage and livestock feeding sectors, for which we substitute 25 percent—their estimate for unrecoverability in the processing sector—which we argue more nearly reflects conditions in the other mostly nonagricultural sectors. This adjustment lowers their estimate of water values. Without presenting all the calculations and changes, these modifications of their data interpretations result in a revised estimate of the capitalized value of out-transferred water of $296.27 per acre-foot in place of their of $295.36, a change of inconsequential magnitude. Thus we confirm part of the authors' contention, viz., that alterations in the manipulations of the *data* do not radically alter the order of magnitude of the value estimate. This net result is merely fortuitous; for example, if one adjusts only the water coefficients, the Hartman-Seastone estimate is reduced by about 9 percent. Changing the assumption on percentage recoverability of other profits lowers their estimate by about 7 percent. Adding grain and forage profits has a 3 percent positive effect. The tax assumption has an upward effect of 13 percent.

However, manipulation of some of their key assumptions and inclusion in the analysis of some elements that they ignore *do* materially affect the order of magnitude of their estimated value of water. To these we now turn.

A crucial assumption of the Hartman-Seastone argument is that if water were transferred from use in the Imperial Valley to use in Los Angeles County by amounts that increase at the rate of 32,900 acre-feet per year as required by the Los Angeles area, all grain and forage crops would disappear in Imperial County in some 30-plus years. At the same time, because the livestock feeding, dairy, poultry, meat and poultry processing, and grain mill products industries are based on the local production of grains and forages, these industries would also completely disappear. Estimates of the direct and indirect effects of these disappearances were made with the aid of the input-output model of the 1954 California economy [3].

Our major disagreement with their analysis is on the basic assumption that all of the livestock and livestock processing industries would disappear as local grain and forage crops are phased out. If these industries were to remain, as we believe they would, the value of an acre-foot of out-transferred water would be materially reduced.

The only evidence given for this all-important assumption is a statement in a previous theoretical chapter [1, ch. 7, p. 82]: "It is generally recognized that locational advantages are gained by locating the feed yards and packing plants near the feed-forage supply, *other things equal*."[3] This statement was supported by a footnote as follows:

[2] At this point, the authors reference Hirschleifer et al. [2].

[3] Emphasis added.

This conclusion was affirmed by Professor David Seckler at Colorado State University who is part owner of a vertically integrated irrigated cropland-feed-yard-packing plant operation located at Sterling and Wray, Colorado. Hugh Winn, livestock marketing specialist at Colorado State University, also affirmed this conclusion and provided additional information on the competitiveness of this industry.

We do not disagree with the quoted authorities. We only argue that in the arid Southwest, *other things are not equal.* In the Imperial Valley, as in Arizona, cattle feeding has a comparative advantage in livestock feeding which is independent of local feed production. Both areas have high efficiency of feed conversion due to the hot, dry climate. Both are near large centers of population in which to market their product. Both already import large quantities of feed grains from the Southern Great Plains. (Arizona, while a net grain exporter, has traditionally exported most of its local supply and imported the grain it actually feeds.) Feed grain and forage prices in the Imperial Valley and in Arizona are now dominated by their price in the deficit areas of California less cost of transportation. Forage is becoming a less important input into the feeding industry at the same time that pelleting technology is reducing its transportation and handling costs. Hence, it may be plausibly deduced that the livestock feeding and processing industry in the Imperial Valley is not dependent on locally grown feed grain and forage supplies but upon the comparative advantage of its feed conversion ratios and the existence of a deficit feed grain and forage demand in the Los Angeles basin and central Californa.[4]

Therefore, we have made alternative estimates of the value of an acre-foot of out-transferred water under our alternative assumption—that the indirect effects on the Imperial Valley economy would include only the backward linkages from the disappearance of forage and feed grains and not the forward linkages assumed in the Hartman-Seastone analysis.

Once the assumption of only backward linkages is recognized, Table 18 and Figure 11 of Hartman and Seastone become almost irrelevant. They lead to some confusion [1, pp. 103–104] even for the purpose of their own analysis. Their Table 18 lists the direct and indirect total water use per year resulting from deliveries to *final demand* of all the agricultural sectors in the area. Attached to these estimates are rent, profits, and wage estimates in dollars per acre-foot per year, the sum of the products of which lead to an estimate of total "value added" generated annually by total water use in the area. Figure 11 graphs the results of Table 18.

The confusion can be generated if the lay public compares water totals to value totals to obtain an *average* value per acre-foot per year. This would be approximately $154 per acre-foot per year for all agricultural industries in the region. Even under the forward linkage assumptions, only food and feed grains, livestock group, and grain mill products sectors are at the margin where, if they were all totally eliminated, an average annual value would be relevant. This value would come to about $89 per acre-foot per year (using Hartman and Seastone original estimates). Much of this value is recoverable, and so the final unrecoverable value per acre-foot per year (including unrecoverable wages lost) if total disappearance occurred would be about $14.75 ($295.36×.05) [1, Table 19 and p. 107].

If, as we assume, only backward linkages occur, our Tables 1, 2, and 3 present the relevant information. Table 1 shows that $29,453,000 of gross output per year are generated by the two marginal sectors using 1,332,201 (our estimate) acre-feet of water per year. Average *direct total value* (not value added) is only $22.11 per acre-foot per year. The data in Tables 2 and 3 (col. 2) show that direct value added per year is $14.12 for food and feed grains and $14.70 for forage. Indirect value added generated annually from backward linkages is $4.97 for grains and $4.70 for forage. Thus total direct and indirect value added per acre-foot per annum is $19.09 for grains and $19.40 for forage.[5]

Table 1. Total output and water use for the affected sectors

Sector	Gross domestic output	Total direct water use: Hartman-Seastone estimate	Total direct water use: Our estimate
	thousand dollars	*acre-feet*	
1. Food and feed grains	10,375.9	241,862	436,722
4. Forage	19 077.1	890,519	895,479
Total	29 453.0	1,132,381	1,332,201

[4] Research is under way at Arizona to empirically test this hypothesis.

[5] The income multipliers on which Tables 2 and 3 are based are "adjusted" income multipliers since they are related to per dollar changes in output rather than per dollar changes in final demand. The difference is explained in [3, p. 14] as follows: ". . . interdependence coefficients (A_{ij}) may be 'scaled down' to reflect only the direct and indirect effects of *output changes* by dividing each column entry . . . by that column's diagonal element. That is, each A_{ij} is divided by its corresponding A_{ij} for $i=j$. The result is to net out internal flows (requirements from industry i by industry i) generated by final demand for industry i as well as further flows from other sectors induced by these internal flows. Output requirements from industry i per dollar of final demand for industry i are now exactly one dollar. Output requirements from other sectors per dollar of final demand for industry i are thus, in effect, per dollar of output of industry i." Adjusted multipliers were used since it is the decrease in output rather than the decrease in final demand that is being measured under our backward-linkage-only assumption. The result was to scale

Table 2. Food and feed grain income multipliers and estimates of capitalized income losses, assuming backward linkages only

Income component	Income multiplier[a]	Income per acre-foot[b] per year	Unrecoverable income per acre-foot per year	Capitalized income flow[c]	Capitalized income flow[d]
			dollars		
Rent					
Direct	.250	5.75	5.75	115.00	71.88
Indirect	.000	—	—	—	—
Wages					
Direct	.161	3.70	[e] 3.48	—	—
Indirect	.142	3.26	[e]	—	—
Profits					
Direct	.203	4.67	2.24[f]	27.91	22.00
Indirect	.074	1.71	.43[g]	5.36	4.22
Total				148.27[h]	98.10[i]

[a] Value added, by component of value added, per dollar of change in *output* of the food and feed grain sector.
[b] Income multiplier divided by revised water coefficient of .0435.
[c] Assuming planning horizons of infinity and 20 years for land rent and profits, respectively, capitalized at 5 percent.
[d] Assuming planning horizons of 20 years and 14 years for land rent and profits, respectively, capitalized at 5 percent. This assumption is equivalent to the same planning horizons as under (c) above, but using a capitalization rate of 8 percent.
[e] A total one-shot wage loss of $3.48 (one-half year's wages).
[f] Forty-eight percent of col. 2 entry.
[g] Twenty-five percent of col. 2 entry.
[h] $148.27 of capitalized income flow plus $3.48 for six months of wages lost gives a total value of $151.75 per acre-foot of perpetual right to one acre-foot of water per year.
[i] $98.10 of capitalized income flow plus $3.48 for six months of wages lost gives a total value of $101.58 per acre-foot of perpetual right to one acre-foot of water per year.

Table 3. Forage income multipliers and estimates of capitalized income losses, assuming backward linkages only

Income component	Income multiplier[a]	Income per acre-foot[b] per year	Unrecoverable income per acre-foot per year	Capitalized income flow[c]	Capitalized income flow[d]
			dollars		
Rent					
Direct	.250	5.31	5.31	106.20	66.38
Indirect	.000	—	—	—	—
Wages					
Direct	.306	6.50	[e] 4.78	—	—
Indirect	.144	3.06	[e]	—	—
Profits					
Direct	.136	2.89	1.39[f]	17.32	13.65
Indirect	.077	1.64	.41[g]	5.11	4.03
Total				128.63[h]	84.06[i]

[a] Value added, by component of value added, per dollar of change in *output* of the food and feed grain sector.
[b] Income multiplier divided by revised water coefficient of .0471.
[c] Assuming planning horizons of infinity and 20 years of land rent and profits, respectively, capitalized at 5 percent.
[d] Assuming planning horizons of 20 years and 14 years for land rent and profits, respectively, capitalized at 5 percent. This assumption is equivalent to the same planning horizons as under (c) above, but using a capitalization rate of 8 percent.
[e] A total one-shot wage loss of $4.78 (one-half year's wages).
[f] Forty-eight percent of col. 2 entry.
[g] Twenty-five percent of col. 2 entry.
[h] $128.63 of capitalized income flow plus $4.78 for six months of wages lost gives a total value of $133.41 per acre-foot of perpetual right to one acre-foot of water per year.
[i] $84.06 of capitalized income flow plus $4.78 for six months of wages lost gives a total value of $88.84 per acre-foot of perpetual right to one acre-foot of water per year.

As Hartman and Seastone point out, much of this foregone income would be recoverable as water is transferred from these uses to others. Using their procedure, we estimate nonrecoverable income to be $7.41 per acre-foot per year plus a one-shot wage payment of $3.48 for grains and $6.43 per acre-foot per year plus a one-shot wage payment of $4.78 for forages.

When these annual values are capitalized at 5 percent (to infinity for land and over 20 years for capital facilities), these values plus the one-half year loss of wages income become total values of $151.75 (footnote h, Table 2) for grains and $133.41 (footnote h, Table 3) for forages per acre-foot of perpetual right to one acre-foot of water per year. Because these are capital values of the right to receive an acre-foot of water per year in perpetuity and the discount rate used in their derivation is 5 percent, the value of an acre-foot of flow per year used for these purposes is ($151.75×.05) or $.7.59 for grains and ($133.41×.05) or $6.67 for forages, values materially lower (half or more) than those estimated by Hartman and Seastone.

In the concluding paragraphs of their chapter 8 they say, "It is quite obvious that the critical *assumptions concern the amount of immobility in capital, land, and labor resources*."[6] They are correct, of course, but, as indicated above, they should have added "and the substitutability of other inputs to the processing sectors for those that will disappear from local production." They do mention the importance of input substitutability in such analyses in their theoretical chapter 7 [1, p. 83] and again in their final conclusions [1, ch. 9, pp. 123 and 124], but they choose to ignore it, by assumption, in their empirical chapter 8

Another of the key assumptions in the Hartman-Seastone analysis is a discount rate of 5 percent applied to land rent to an infinite horizon and to depreciable and unrecoverable capital facilities to a 20-year horizon. We consider their assumption of 5 percent to be acceptable as an opportunity interest rate as a current earning demand on investments in unrecoverable land and capital facilities. We consider it highly dubious, however, that the expected earning capacity of these assets should be capitalized at this rate to planning horizons as distant as infinity and 20 years respectively, due to risks and uncertainties, even by the public sector. Let us alter their assumption by the plausible presumption that land rent would be capitalized to a 20-year horizon at 5 percent (equivalent to an 8 percent discount rate in perpetuity). In like manner, let us assume the same implied 3 percent "risk and uncertainty" discount rate on depreciable unrecoverable capital facilities and thus use 8 percent for 20 years to capitalize the income flowing from these assets. (This is equivalent to current earnings of 5 percent for a shorter period of approximately 14 years.)

Substituting these capitalization factors into the calculations in Tables 2 and 3, we derive capitalized water values (including wage losses) of $101.58 per acre-foot for grains and $88.84 for forage, as shown in footnote i of Tables 2 and 3, respectively. Because these are present values for a perpetual right to receive one acre-foot of water per year and because the opportunity cost interest rate for current earning from this investment is taken to be 5 percent, the average annual equivalent value of this water flow to an infinite horizon is ($101.58×.05) or $5.08 per acre-foot for grains and ($88.84×.05) or $4.44 for forages.

Again the significance of altering a key assumption in the estimates is revealed. The estimated value of an out-transferred acre-foot of water has been reduced by a third merely by altering the assumed capitalization horizon.

But there is another side to the argument. There are elements in the value of an acre-foot of out-transferred water that Hartman-Seastone did not include in their estimate. Including them will alter estimates upward. They mentioned two such omissions—the effect of the houshold consumption multiplier and the accumulative effect on the public sector through loss of tax revenues and reduction in use of public facilities. In our above revisions of their estimates, we have partly corrected for one of these omissions by adding taxes paid back into the estimates of incomes lost. Thus the loss of tax revenues is allowed for in our revised estimates although the effects of the balance of these omissions are not.

But of much greater importance among omissions from their estimates is one not even mentioned by them, although the basis for its inclusion was explicitly laid down by them in their theoretical model in chapter 2. That omission is the impact on the Salton Sea following upon transfer of irrigation water out of the Imperial Valley. The sea is a recreational resource experiencing rapidly growing demand largely from southern California coastal residents. It is fed largely by return flow from irrigation in the Valley. As conceptualized by the authors in their chapter 2, the recreational industry on the Salton Sea may experience a "technological external diseconomy" which must be included in any measure of the cost of transfer. Doing so could be expected to increase the derived value of out-transferred water.

Where does all this leave us? With a mixture of paradox and incompleteness that may lead to much mischief in the hands of the unwary, the unsophisticated, and the unethical. The incompleteness arises from the numerous omissions from their analysis (most important from the standpoint of policy implications being the total omission of any reference

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down the output multipliers to 95.7 percent and 99.8 percent of their original values for grains and forage, respectively.

[6] Italics in the original.

to, let alone estimate of, the value of transferred water to the receiving area and to the "rest of the world") and from the debatable character of some of their key assumptions. The paradox arises from the apparent circumstance that were we to go to all the trouble to alter data interpretations and key assumptions and to include omitted elements in the estimates of water transfer values to the Imperial Valley, we might come out with an estimated value not far from the Hartman-Seastone estimate. But, of course, this really is no paradox; it is but a circumstance coincident to the empirical conditions of the Imperial Valley.

What we really are left with is total ignorance of the economic efficiency of a transfer of water out of the Imperial Valley to the California coast and a wholly inadequate estimate of the value of out-transferred water even to the Imperial Valley economy itself.

Thus may mischief arise due to the sanctity with which such estimates are clothed by virtue of their formalization in print under the professional aegis of two capable and reputable economic analysts and the highly respected imprimatur of RFF. From these considerations arose Kelso's concluding sentence of his review of the Hartman-Seastone book, "This reviewer wishes the authors had left it [chapter 8] out entirely or had developed it more cogently and completely," a wish we reiterate here.

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ECONOMETRIC STUDIES OF MILK MARKETING: COMMENT

This communication reviews two recent *AJAE* articles presenting econometric analyses of portions of the dairy industry. One is Marvin Kottke's model of the New England dairy industry [4]; the other is George Ladd's analysis of federal order blend prices [5].

Both of these involve broader coverage than my own model [2], one confined to the geographic alignment of Class I prices in Federal order markets. Kottke's model uses demand functions for fluid and manufacturing milk and short-term supply response functions to predict the production and disposition of milk in four New England subregions, with upstate New York and Chicago as additional supply areas. An intriguing feature of his model is that it was started at 1965 and predictively extended through 1970, with actual data through 1967 providing a comparison of the predicted and actual outcomes.

An inherent limitation of any such analysis is the construction of demand and supply functions for the submarkets and production areas. Supply response is particularly subject to variations that depend heavily on the time period allowed and to the influences of technological changes and interregional shifts. These basic limitations are illustrated by the fact that milk production in New England declined in 1965 (and since), rather than rising as predicted by the model. Correspondingly, actual blend prices rose to a substantially greater degree than predicted.

In addition, however, Kottke appears to have made a serious conceptual error by devising demand functions for milk for manufacturing purposes in each of his four marketing areas. In practice, fluid markets try to maximize Class I uses and deal with the daily, seasonal, and annual surpluses by converting them to manufactured products as efficiently as possible and selling the products on the national market. Thus, the demand for milk for manufacturing in any given region or subregion is not a linear, down-sloping function. Rather, it is an essentially horizontal function, at about the national support price level.

There are two unrealistic effects of the assumed down-sloping demand curve for manufacturing milk and the inclusion of transportation charges on such milk. One is the unduly low price at the Chicago source. The second is that the bulk of the Vermont milk is assigned to be manufactured rather than shipped for fluid uses, with abnormally low blend prices as a result.

Ladd used historical data to analyze the effect on intermarket differences in blend prices of such fac-

tors as distance from Eau Claire, Wisconsin, percentage of producer milk used in Class I, changes in dairy support levels, supply-demand adjusters, individual handler pooling, and economic index formulas for determining Class I prices.

Ladd and I concur with a 1962 conclusion of the Federal Order Study Committee: "The practice of varying the terms of the orders from market to market tends to magnify these problems of intermarket relationships." I have emphasized Class I price alignment, since these prices are specifically determined by order provisions. By contrast, blend prices on which Ladd centers his attention depend also on the percentage of producer milk used in Class I and are subject to influences outside the scope of regulation.

Ladd's use of 1959–1962 data is a serious shortcoming for an industry and a regulatory program that are changing so rapidly. Moreover, it was not necessary to use such ancient data; the information on price support removals published in his Table 2 has regularly been published by USDA. For example, the *Dairy Situation* for May 1969 carries this series of annual data for the period 1949 through the 1968–69 season. Moreover, this is only one of his minor inputs, so should not have been allowed to so severely outdate the entire analysis.

The reliance on a model using Eau Claire-plus-transportation cost is equally archaic. This is not to detract from Louis Herrmann's pioneer effort [3] which preceded the ready availability of more sophisticated computer models. West and Brandow's spatial equilibrium model published in this Journal in November 1964 [6], Carley and Purcell's reactive programming model of 1965 [1], and mine of April 1968 take into account multiple sources of supply and demand, thus yielding more realistic measures of intermarket price alignments than the Eau Claire model. Eau Claire-plus-freight provides only an upper limit influence on prices in other markets.

There are other defects in the analysis that are only moderately less serious than the age of the data or the reliance on Eau Claire as a base. In equation (1), attributed to Babb, there is no term X_{i2}, but a definition is given for this nonexistent term. A serious conceptual error is contained in the equation on page 628, relative to Class II price. His equation reflects distance from Eau Claire, seasonal factors in the Class I price, and various other Class I price components. Actually, Class II prices have always been set as closely as possible to national manufacturing values, with a minimum of local differences. Such differences as have been allowed reflect efficiencies in manufacturing operations rather than the types of differential that have applied to Class I prices. This misconception of the nature of the Class II price is built into formula (2) and affects the entire subsequent analysis.

Finally, it is a conceptual error that in any given order or group of orders, supply-demand adjusters could "have cushioned the price-depressing effects of decreases in X_4," X_4 being the Class I utilization percentage. It could conceivably be true that a group of orders without supply-demand adjusters may have shown more variation in blend prices than a group having such adjusters. This could occur as a result of such other factors as the presence or absence of economic formulas. However, a supply-demand adjuster geared to the percentage of the supply used in Class I would, by virtue of the arithmetic involved, raise blend prices more rapidly when a shortage develops than if there were no supply-demand adjuster.

These two cases illustrate the fact that econometric studies place heavy demands on reviewers and readers in identifying the symbols, checking the mathematical manipulations, and evaluating the assumptions involved at each step of the process. Kottke's model was exceptionally well presented; it was easy to obtain a visual representation by graphing the supply and demand functions. Ladd's article, on the other hand, shows little evidence of careful review by anyone with a working knowledge of federal orders or of the price support programs.

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ECONOMETRIC STUDIES OF MILK MARKETING: REPLY

Robert Freeman has raised an interesting issue regarding the conceptualization of pricing behavior in the manufacturing milk market. The issue is whether or not to allow for a regional demand influence on price in a spatial allocation model. Freeman argues that he would not make such an allowance. He suggests that demand in any given region is "an essentially horizontal function," i.e., price is taken as given and any quantity offered can be sold in the market at that price. I contend that all regions face a potential limit in the form of price response and, characteristically, such a limitation is conceptualized as a "down-sloping" demand function.

Freeman's suggestion seems to be based largely on the mechanics of pricing. It is true that, in reality, Class II milk prices are computed in each federal order market by using a national basepoint price such as the Minnesota-Wisconsin "milk price paid to farmers." However, it does not follow that the price-making forces that determine the Minnesota-Wisconsin prices reside exclusively in the Minnesota-Wisconsin area. Moreover, milk processors and distributors can hardly ignore consumer price responsiveness in their own markets even though a national market prevails.

Apparently, Freeman's concentration on "slopeless" regional demand functions caused him to overlook the possibility that the two alleged "unrealistic effects" were caused by errors on the supply side, rather than by an assumption of "down-sloping" demand functions. The low milk price for the outside region is, admittedly, unrealistic. However, it resulted from an overestimation of the outside region's milk supply—not from the form of the demand functions. The second effect, that the bulk of Vermont's milk was allocated to manufacturing uses, is not unrealistic. Vermont's milk supply chronically exceeds demand from neighboring fluid markets, and consequently over half of its supply is utilized as manufacturing milk. The reason for Vermont's "abnormally low" solution blend price existed elsewhere in the model. I discovered that the cause was an underestimation of Vermont's Class I price, and this error has been corrected in subsequent applications of the model.

Although I do not subscribe to Freeman's view of a milk market calling for slopeless regional demand functions, I do share his concern that regional manufacturing milk prices should reflect the price support level. Conceptually, this can be done by including a governmental purchasing activity and, since the multistage model incorporates a time dimension, the storage function associated with a price support program can be included.

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ECONOMETRIC STUDIES OF MILK MARKETING: REPLY

Freeman's first criticism of my paper [1] concerns the age of my data. I wanted data for a four-year period in which support price levels and removals (as percentages of marketing) changed substantially between the second and third years and changed little between the first and second and between the third and fourth years. Four years were desired rather than two to obtain greater statistical reliability. Years more recent than 1959–1962 that satisfy these criteria are so recent that necessary data for these years were not available when the study was started. I explained this in my paper. The second sentence in the first paragraph on page 631 probably should have read: "U. S. Department of Agriculture purchases of milk solids and support price levels rose substantially between 1959–60 and 1961–62."

Freeman next complains that the model I used is archaic. Archaic though the model may be, it was not inappropriate for my purposes. The objectives of Freeman, of West and Brandow, and of Carley and Purcell were to find *equilibrium* levels of prices, or of consumption, or of production, or of all three. As I stated on page 625, my objective was to measure *existing* relationships and to test hypotheses concerning these relationships. For their objectives, my procedure would have been inappropriate; for my objectives, their procedure would have been inappropriate. One of the very features that made their procedures appropriate for their objectives renders their procedures inappropriate for my objectives, namely, abstracting of institutional relations from programming models.

We need to remember that all models are inappropriate; different models are simply inappropriate for different things.

As to the complaint that X_{i2} does not appear in equation (1), perhaps my exposition would have been clearer if I had multiplied β_2 by X_{i2} in my equations so that (1), for example, would have read

$$Y_i = \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 X_{i4} + \epsilon_i$$

This may have been a presentational defect, but it was not an analytical defect.

Freeman objects to my relation (appearing on page 628):

$$P_{i2} = f_2(X_{i3}, X_{i4}, \cdots, X_{i10})$$

Apparently he would have preferred the relation

$$P_{i2} = F_2(\bar{P})$$

where $\bar{P}$ is national annual average manufacturing milk price. Since $\bar{P}$ has the same value for every market, it cannot account for intermarket differences in prices. Since my purpose was to analyze intermarket price differences, the inclusion of $\bar{P}$ in (2) would not have contributed anything to my analysis.

Neither theory nor previous empirical work tells us what form functions such as equation (2) should be. I chose to estimate (3) because (a) it allows for interaction effects and (b) it is a simple functional form. Even if my expression for P_{i2} were replaced by $P_{i2}=F_2(\bar{P})$, these two criteria would still have led me to use equation (3). This replacement would not have changed any of the hypotheses listed in Table 3 on page 632; neither would it have changed anything from page 633 to the end of the paper. This replacement would have made the βs in equation (3) functions of $\bar{P}$. Any effect of variations in $\bar{P}$ can be reflected only in analyses containing data for more than one year. During 1959–1962, annual values of $\bar{P}$ were closely related to annual price support levels and to annual price support removals from the market. I tested for effects of changes in the price support program on the βs by using F tests [1, Table 4, page 633] and by allowing intercepts to vary among years [1, Table 5, page 634].

Hence, even if I accept his proposition that formula (2) is based on a "misconception of the nature of the Class II price," I do not accept his conclusion that "this misconception . . . affects the entire subsequent analysis." And, having seen no evidence on the relation of P_{i2} to $X_{i3}, X_{i5}, \cdots, X_{i10}$, I am not convinced that (2) is based upon a misconception; I am ready to admit that it may be.

My first response to his statement concerning the "conceptual impossibility" of the effects I attribute to supply-demand adjusters on page 636 is to paraphrase Hamlet (Scene V, Act I) when he says,

> There are more things in heaven
> and earth, Horatio,
> Than are dreamt of in your
> philosophy.

My paraphrase is:

> There are more things in heaven
> and earth, Mr. Freeman,
> Than are explicable by our
> economic concepts.

Or, in less elegant language:

> What is to be will be,
> What ain't to be might happen.

The fact that something is "conceptually impossible" does not make it "factually impossible." Granted, my statistical results and my interpretation of them are not consistent with our conception of what supply-demand adjusters *ought* to accomplish. I wish that in addition to rejecting my interpretation of the relation $\Delta Y/\Delta X_4 = 0.026-0.004X_{10} + \cdots$, Mr. Freeman had presented us a conceptually correct interpretation of the inconsistency between theoretical expectations and empirical results.

I cannot agree with his contention that differences I have attributed to supply-demand adjusters are due to other differences in order provisions. My equations contained "such other factors as the presence or absence of economic formulas" and other differences in order provisions. If orders without supply-demand adjusters showed more variation in blend prices because of other factors, the coefficients of these other factors (not of supply-demand adjuster) should explain the difference.

As my acknowledgments indicated, earlier drafts of my report were read by Emerson Babb, Alden Manchester, and J. R. Strain. I certainly do not agree that these people lack a "working knowledge of federal orders or of the price support program." Whether they reviewed the manuscript carefully I cannot say, but I know that they provided some helpful criticisms. A number of the comments of the anonymous reviewers for this Journal lead me to believe they know a good deal about federal orders and that they had read the manuscript carefully.

It may be, of course, that my paper "shows little evidence of careful review" because I failed to incorporate the best suggestions of the reviewers and editors into the final draft.

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Reference

[1] Ladd, George W., "Federal Milk Order Provisions: Effects on Producer Prices and Intermarket Price Relationships," *Am. J. Agr. Econ.* 51:625–641, Aug. 1969.

POSITIVISTIC MEASURES OF AGGREGATE SUPPLY ELASTICITIES: SOME NEW APPROACHES—SOME CRITICAL NOTES

The analysis of supply made by Tweeten and Quance [1] is of special methodological interest for econometric analyses using least squares. The purpose of this note is to show that the authors' method of solution is mathematically incorrect both for (1) quantification of irreversible supply reactions to in-

creasing and decreasing prices and (2) differentiating the partial influence of an independent variable during certain periods of investigation.

The Problem of Irreversibility

The problem of irreversibility is not limited to price-supply relations but is of fundamental importance for analysis of many economic relations. However, the use of least squares or related methods of estimation which assume reversibility of relation creates especially serious problems in estimating demand and supply functions. Specifically, inclusion of one or more irreversible independent variables into a function affects the analysis in two respects:

(1) The partial influence of each independent variable cannot be determined exactly;

(2) The coefficients of all other independent variables can be distorted—even a change of signs is possible [2, p. 8].

Tweeten and Quance have treated the irreversible reaction of supply to price changes by splitting the price variable into one variable for increasing prices and another variable for decreasing prices. Their method of splitting variables is described as follows: "When $P_r/P_p{}^{t-1}$ is for a specified period or for years of declining or increasing prices, it is the actual observation for the specified years but has a zero value for other years in the period observed (1957–59 = 100)" [1, p. 343].

It can be proved, however, that the quantification of irreversible relations cannot be done by this method. Supposing that the residual variance = 0, the case of reversibility is shown in equation (1):

$$(1)\quad y_i = a_0 + a_k x_{ik} \qquad \text{for } i = 1, \cdots, n \text{ and } k = 1, \cdots, m$$

y = dependent variable

a_0 = additive constant

a_k = coefficient of regression

x_k = independent variable

Applying the splitting procedure suggested by Tweeten and Quance, equation (1) can also be written as

$$(2)\qquad y_i = a_0 + a_k x_{ik}' + a_k x_{ik}''.$$

Variables x_k' and x_k'' stand, respectively, for the increasing and decreasing phase of variable x_k, where

$$x_{ik}' = 0, \text{ if } x_{ik}'' > 0 \quad \text{and} \quad x_{ik}'' = 0, \text{ if } x_{ik}' > 0.$$

Because of the assumed reversible relation between y and x_k the coefficients of regression a_k of variables x_k' and x_k'' are equal; hence it also follows that a_0 as defined within the system comprising n equations is constant.

In the case of reversibility this method of variable splitting is absolutely correct. Its application, however, is unnecessary since it gives no additional information.

Given an irreversible relation between y and x_k, equation (2) becomes (3):

$$(3)\qquad y_i = a_{i0} + a_k' x_{ik}' + a_k'' x_{ik}'',$$

where

$$a_k' \neq a_k''.$$

Depending on whether in the particular equations $x_i'{}_k > 0$ or $x_i''{}_k > 0$ (the corresponding value of the other variable being equal to zero), the n equations may give rise to a maximum of n varying a_0 values. In constrast, a_0 represents a constant in the solution, obtained on the basis of the method of least squares. This deviation of the estimated a_0 value from the real a_{i0} values of the particular equations causes an incorrect estimation of parameters a_k' and a_k''. An exception is given in the case of irreversibility between the dependent and independent variable but where the independent variable shows fluctuations in only one direction.

The following describes briefly a method of solution for the mathematical treatment of irreversible reactions, applying the method of least squares [2, p. 14], which also splits the respective independent variable into an increasing and a decreasing phase, thus complying with the following requirement: The variance of the dependent variable explained by the two newly formed variables has to correspond to the actual variance which has been caused by the particular independent variable.

The splitting procedure is based on the calculation of first differences (Δx_{jk}) of observation values of the independent variable:

$$(4)\quad \Delta x_{jk} = x_{ik} - x_{i-1,k} \qquad \text{for } i = 2, 3, \cdots, n \text{ and } j = 1, 2, \cdots, n-1$$

The $n-1$ first differences which occur (n = number of observation values) are used for the formation of a x_k' variable for the increasing and a x_k'' variable for the decreasing phase.

Considering the above condition, the following should be demanded of variables x_k' and x_k'':

(1) In each case the opposite effect must be completely eliminated. This is done by

(a) separation of Δx_{jk} into $\Delta x_{lk} \geq 0$ and $\Delta x_{rk} \leq 0$;

(b) the use of $x_{ik}' = x_i'{}_{-1,k}$, if $\Delta x_{jk} \leq 0$ and of $x_{ik}'' = x_i''{}_{-1,k}$, if $\Delta x_{jk} \geq 0$.

(2) The number of observation values must remain constant; by realizing (1), this condition is fulfilled.

(3) The sequence of rates of change and thus the position of the respective positive or negative changes within the sequence may not be altered.

Starting from these requirements the formation of the two variables is effected in the following manner:

The x_k' variable is formed by adding the first differences $\Delta x_{lk} \geq 0$ to an initial value which can be any value ≥ 0. It is advisable, however, to start from the first observed datum of the initial variable that enables the identification of the initial variable.

Table 1. The data of the model

Original variables		Splitting of x-variables according to:			
		Tweeten and Quance		Wolffram	
y	x	x'	x''	x'	x''
20	10	10	0	10	10
35	13	13	0	13	10
29	11	0	11	13	12
44	14	14	0	16	12
59	17	17	0	19	12
44	12	0	12	19	17
35	9	0	9	19	20
70	16	16	0	26	20
90	20	20	0	30	20
84	18	0	18	30	22

The mathematical procedure is summarized in the following system of equations:

$$\begin{aligned} x'_{1k} &= x_{1k} \\ x'_{2k} &= x'_{1k} + \phi\,(x_{2k} - x_{1k}) \\ x'_{3k} &= x'_{2k} + \phi\,(x_{3k} - x_{2k}) \\ &\vdots \\ x'_{ik} &= x'_{i-1,k} + \phi\,(x_{ik} - x_{i-1,k}) \\ &\vdots \\ x'_{nk} &= x'_{n-1,k} + \phi\,(x_{nk} - x_{n-1,k}) \end{aligned}$$

x_{1k} = first data of initial variable x_k

$$\phi = 1 \quad \text{if } (x_{ik} - x_{i-1,k}) > 0$$
$$\phi = 0 \quad \text{if } (x_{ik} - x_{i-1,k}) < 0$$

Starting from $\Delta\ x_{rk} \leq 0$, the x_k'' variable is prepared in an analogous way. Thereby the addition of the first differences $\Delta\ x_{rk} \leq 0$ to an initial value can be effected, considering the sign or absolute value.

$$\begin{aligned} x_{1k}'' &= x_{1k} \\ x_{2k}'' &= x_{1k}'' + (1 - \phi)(x_{2k} - x_{1k}) \\ x_{3k}'' &= x_{2k}'' + (1 - \phi)(x_{3k} - x_{2k}) \\ &\vdots \\ x_{ik}'' &= x_{i-1,k}'' + (1 - \phi)(x_{ik} - x_{i-1,k}) \\ &\vdots \\ x_{nk}'' &= x_{n-1,k}'' + (1 - \phi)(x_{nk} - x_{n-1,k}) \end{aligned}$$

The computed coefficients differ only with respect to the sign. The transformation of data into logarithms should be done before the variables are split.

With the model of an assumed irreversible relation between the dependent and independent variables, where the residual variance $=0$, it can be demonstrated that the estimation equation cannot be determined exactly with the procedure suggested by Tweeten and Quance [1, p. 343].

The general function of this model

$$y = f(x) \tag{5}$$

is based on the following equation:

$$y_i = a_0 + 5x_i' + 3x_i'' \quad (R^2 = 1) \tag{6}$$

In equation (6) the independent variable x has been split into the increasing phase x' and decreasing phase x''. The initial data of the model, as well as the variables resulting from the corresponding splitting procedure, are shown in Table 1.

Applying the procedure of Tweeten and Quance for the splitting of variables, the following estimation equation (7) results:

$$y_i = -43{,}16 + 6{,}25x_i' + 6{,}99x_i'' + u_i \quad (R^2 = 0{,}912) \tag{7}$$

u_i = residual variance

Both regression coefficients differ greatly from the assumed coefficients of the model; thus, $R^2 < 1$. On the other hand, the coefficients can be determined by the proposed method of forming the variables x' and x'' of the first differences of the original variables, as shown by equation (8):

$$y_i = 0 + 5x_i' - 3x_i'' \quad (R^2 = 1) \quad (u_i = 0) \tag{8}$$

The Splitting of Variables into Partial Time Periods

Attempts to quantify the differing influence of an independent variable in various periods under investigation by "segmentation" of the variable has also been done by other authors. The number of the newly formed variables corresponds in this case to the number of periods, where the particular variables are so constructed that the respective period of analysis contains the actual values observed, whereas all other serial values are set equal to zero [1, p. 345].

The application of this splitting procedure is mathematically correct only if the coefficients of regression in the individual periods are equal, that is, if the influence of the independent variable over the total period of investigation is constant. Segmentation of this kind—according to the method of solution suggested by Tweeten and Quance regarding irreversibility—is proved useless, as it does not furnish any additional information. Where the effect of a variable is not constant over time, coefficients for all individual periods cannot be determined exactly, as the constancy of the additive constant is not given in such a system of equations. This problem is comparable to the one of irreversibility.

This procedure becomes practical with the following alteration: Instead of zeros, the lacking serial values at the end and beginning of the newly formed

variable are replaced by the last observation value of each preceding period. The alteration of influence can be regarded also in calculating with moving periods over a shorter period of time.

Summary

This note proves that Tweeten and Quance [1] applied a mathematically inexact procedure of quantifying irreversible relations between the dependent and independent variables on the one hand and the varying influence of an independent variable during a time of investigation on the other hand. The author [2] offers two methods of solving the two problems.

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References

[1] TWEETEN, LUTHER G., AND C. LEROY QUANCE, "Positivistic Measures of Aggregate Supply Elasticities: Some New Approaches," *Am. J. Agr. Econ.* 51:342–352, May 1969.

[2] WOLFFRAM, RUDOLF, "Die Irreversibilität von Angebots- und Nachfragefunktionen," Habilitation thesis, Kiel 1970.

TECHNIQUES FOR SEGMENTING INDEPENDENT VARIABLES IN REGRESSION ANALYSIS: REPLY*

Wolffram's technique for handling segmented variables is clearly superior to the approach we used in equation 7 of our supply response study [1, p. 344]. We had not found his approach presented in the literature and it is a significant methodological contribution, one which econometricians should consider in future efforts to segment variables.

Our reply deals with two issues. One is the recommendation that a dummy 0–1 variable be added to allow for different intercepts as well as slopes of supply curves with increasing and decreasing prices. The second is to apply Wolffram's technique to our supply data in an attempt to improve on our previous estimate of equation 7.

Allowing Different Intercepts

A variation of the Wolffram example is presented in Table 1. His example contained a single independent variable with a zero intercept and thus a unitary elasticity. Equations 1 and 2 apply the Tweeten-Quance (T-Q) and Wolffram (W) techniques respectively to the hypothetical data presented by Wolffram, except that a constant is added to the dependent variable. In keeping with the hypothesis of a different response to increasing and decreasing values of X, the constant was taken as 3 for increasing observations of X and 5 for decreasing observations. Adding the two constants prohibited either the T-Q or W model from predicting the true constants, and the equations also failed to exactly estimate the true coefficients of X' and X''. But the W parameter estimates were much closer than the T-Q estimates.[1] And the W model resulted in an R^2 of 1.00 compared to .95 from the T-Q model.

The different constants are accounted for in equations 4 and 5 by inserting a dummy variable D with a value of 1 for decreasing observations of X and 0 for increasing values of X. The W model predicts the true parameters in equation 4, whereas the T-Q estimates in equation 5 err about the same as in equation 1.

To add further realism to the example, a second independent variable, V, highly correlated with $X(r=.95)$, was added to equations 3 and 4. The results are not shown, but the W model again predicted the true parameters whereas the T-Q estimates erred greatly. To bring our example more into line with reality, a random element from a normal distribution with zero mean and a variance of 2 was added to the output variable Y. The results are similar to the above findings. All the resulting estimates deviated somewhat from the true parameters, but the W estimates again were more accurate than the T-Q estimates.

In the several equations estimated and described above, the coefficients of X' and X'' in the T-Q model tended to be equal, contrary to their true values. This raises doubts about the usefulness of the T-Q model in testing for differences in the coefficients.

Application of Wolffram Techniques to Actual Supply Data

The important question now is whether the promising Wolffram technique could improve our supply response estimates. To answer this question, we estimated equation 7 from our original paper [1,

* Journal Article 2127, Oklahoma Agricultural Experiment Station. Views and estimates presented are the authors' and are not necessarily those of the U. S. Department of Agriculture. We extend our appreciation to Lester V. Manderscheid for useful comments on this subject.

[1] The Wolffram model results in the "wrong" sign on the estimated parameter for the decreasing value of X because of the way the variable is constructed. This sign must be reversed in making inferences.

Table 1. Estimated function under various modifications of the Wolffram (W) and Tweeten-Quance (T-Q) models

General Specification	Equation	Model	R^2	A^a	Estimated parameters of		
					X'	X''	D
Actual parameters				3 or 5	5	3	2
Actual relationship specified by Wolffram (equation 6) with a constant 3 added to Y for increasing observations of X and 5 added to Y for decreasing observations of X	1	T−Q	.95	−36.21	6.19	7.07	na
	2	W	1.00	2.26	4.82	−2.68	na
Same as above except that a 0–1 dummy independent variable D was added to account for the different intercepts of the increasing and decreasing observations of X	3	T−Q	.96	−50.00	7.07	6.09	26.89
	4	W	1.00	3.00	5.00	−3.00	2.00

[a] The true constant in equations 1 and 2 is 3 for increasing prices; 5 for decreasing prices. The true constant in equations 3 and 4 is $A=3$ for increasing prices; for decreasing prices it is $A+D=5$.

Table 1], using both the T-Q and W techniques and adding to each the "dummy" variable D, which proved useful in the above example, to allow for different supply constants for increasing and decreasing prices. The resulting equations (5) for the T-Q model and (6) for the W model are disappointing:

$$
\begin{aligned}
Q^t = &-19.78 + \underset{(.0219)}{.0415}\,(P_r/P_p)_d^{t-1} \\
&+ \underset{(.0231)}{.0676}\,(P_r/P_p)_i^{t-1} + \underset{(.0638)}{.9634}\,T + \underset{(.0561)}{.1804}\,Q^{t-1} \\
&+ \underset{(3.504)}{2.622}\,D \\
R^2 = &\ .9967
\end{aligned}
\tag{5}
$$

$$
\begin{aligned}
Q^t = &-10.92 - \underset{(.0226)}{.0654}\,(P_r/P_p)_d^{t-1} \\
&+ \underset{(.0166)}{.0424}\,(P_r/P_p)_i^{t-1} + \underset{(.0744)}{.9958}\,T + \underset{(.0584)}{.2003}\,Q^{t-1} \\
&- \underset{(.5361)}{.3385}\,D \\
R^2 = &\ .9965
\end{aligned}
\tag{6}
$$

The notation d and i refer respectively to decreasing and increasing prices. P_r is prices received by farmers, P_p is prices paid by framers, Q is output, and T is time. Standard errors are in parentheses. The coefficient of the dummy variable D is not significant in either model. Thus, the hypothesis of different supply constants for increasing and decreasing prices is not supported. Adding the dummy variable D did result in a larger coefficient for increasing prices than for decreasing prices in the T-Q model, a change in conformity with fixed asset theory. The original form of (5), excluding D, showed no difference in coefficients. Contrary to economic theory, the coefficient for declining prices in the Wolffram model is larger than the coefficient for increasing prices.

In summary, the Wolffram technique for segmenting variables is superior to ours and should be employed when the analyst has reason to expect that responses differ between segments of an independent variable. We recommend adding a dummy 0–1 variable to his technique to allow a different intercept as well as slope.

In equation 7 in our supply study [1, p. 344], in which we segmented the price variable, no difference was found in the response of output to increasing and decreasing prices—perhaps because our approach appears to be biased toward similar coefficients for the components of the segmented variable. Using other methodologies in the original study, we nevertheless concluded that the supply elasticity was greater for increasing than for decreasing prices.

Application of the Wolffram technique with and without a dummy variable D added no acceptable new information to our original findings; in fact, his approach showed a greater output response to decreasing than to increasing prices. We continue to endorse the final estimates of the supply elasticities given in our earlier study.

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Reference

[1] TWEETEN, LUTHER G., AND C. LEROY QUANCE, "Positivistic Measures of Aggregate Supply Elasticities: Some New Approaches," *Am. J. Agr. Econ.* 51:342–352, May 1969.

TEMPORAL RELATIONSHIPS AMONG FUTURES PRICES: COMMENT

In a recent article in this Journal, Professors Tomek and Gray [1] claim to have found important basic differences in temporal price relationships between futures markets for commodities having continuous inventories and futures markets for commodities lacking such inventories. Examination of their criteria and evidence suggests that they have overstated their case and that the differences are a matter of degree rather than a matter of kind.

Two empirical criteria for contrasting potato futures price movements with corn and soybean futures price movements are employed in the article. One involves the regression of the closing price of the new crop future at expiration on its April 30 price. The other is a revenue variability criterion involving an F test of the difference between the variance of the price of the new crop future on April 30 and the variance of the price of the same future at expiration. Closer examination suggests that neither of these criteria is appropriate.

The most obvious shortcoming shows up in the application of the revenue variability criterion to corn and soybeans. The measures of variability employed are the variances (or standard deviations) of each price about its mean for the entire 17-year period. The resulting variance ratio would be meaningful if it could be assumed that these yearly deviations from the mean were random. However, it is a dubious criterion to use when the deviations are systematically related to other variables.

During the period studied, 1952–1968, the price support level for corn varied between \$1.00 per bushel and \$1.60 per bushel while soybean price supports varied from \$1.85 to \$2.56. Since the support prices were announced each year prior to April 30, it is reasonable to assume that farmers and traders took these into consideration when forming their price expectations on that date. Indeed, futures prices followed support prices rather closely over the period, as can be seen by inserting the support price in the Tomek-Gray Figures 1 and 2.[1] The simple correlations between the respective support prices and the closing futures price on April 30 were .80 for December corn and .91 for November soybeans. Apparently the whole price structure, including producers' expected prices, shifted up and down with the support price over the period for both commodities.

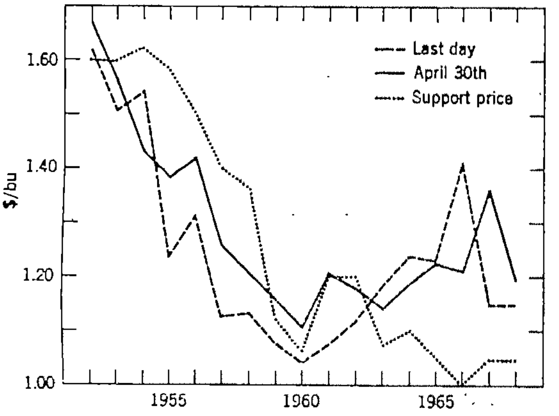

Figure 1. Corn support price to cooperators and closing prices of December corn contract on April 30 and expiration date, 1952–1968

It is obvious that the revenue variability criterion is not meaningful when applied to corn and soybeans in recent years because of the impact of the support programs. Consequently it provides no basis for contrasting these markets with potatoes, and the conclusion that "routine hedging by producers in such markets is unlikely to stabilize their revenues" is unwarranted.[2]

Turning to the regression criterion used in the article, we find results reported that are inconsistent

[1] For 1956–1958 the corn support prices shown in Figure 1 and used in the calculations are the prices applicable to cooperators. The prices used for 1963–1968 do not include support payments to producers.

[2] Results based upon an alternative criterion, involving a more plausible assumption about producers' price expectations, suggest that corn and soybean producers can reduce risk through hedging even while supports are in effect. Suppose, for example, that a producer adopts the support price, plus or minus a constant to take care of location and quality differences, etc., as his expected price at planting time. An appropriate measure of his price risk would be the standard deviation of the difference between the price received and the support price. Measures of the variability of this difference for corn and soybeans over the 1952–1968 period are shown in the table below. The F test for the difference in variance is significant at the 1 percent level for soybeans, providing strong evidence that hedging in the new crop future can reduce price risk for producers who base their price expectations on the support price. For corn the evidence is weaker and the F test is significant at the 25 percent level.

Selected measures of price variability for corn and soybeans, 1952-1968

Price variable	Mean	Standard deviation	F ratio
	cents per bushel		
Difference between the December future and the support for corn			
April 30 close	1.90	14.47	
Last day close	−2.56	18.81	1.69
Difference between the November future and the support for soybeans			
April 30 close	23.57	9.41	
Last day close	31.91	17.58	3.49

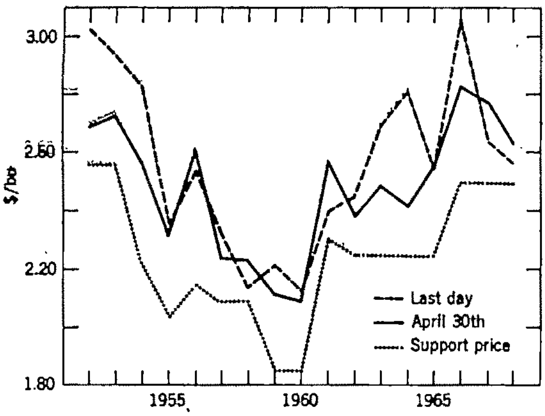

Figure 2. Soybean support price and closing prices of November soybean contract on April 30 and expiration date, 1952–1968

with the competitive nature of futures trading. The regression equations employed provide forecasts in April of the prices of the new crop futures at expiration. If the forecasts were the same as the April 30 prices of the futures, the regression coefficients would be unity and the intercepts would be zero. But any statistically significant differences from these values, such as those reported for potatoes, imply that changes in the new crop futures price can be predicted with success. Such results, if valid, would provide a basis for profitable speculation.[3] Our knowledge of futures trading suggests that any simple analysis that leads directly to the promise of speculative profits deserves to be regarded with supicion. It seems unlikely that a criterion that requires such results for identifying differences can be very useful.

[3] Disregarding trading costs, the predicted profit from holding a long position from April 30 to the expiration of the contract is

$$\hat{\pi} = a + (b - 1)x$$

where a is the intercept, b is the regression coefficient, and x is the April 30 price of the future. We note that when either a is different from zero or b is different from unity, nonzero profits are predicted for some values of x. The decision rule implied for speculators is to hold a long position whenever $\hat{\pi} > 0$ and a short position whenever $\hat{\pi} < 0$.

Table 1. Regression of the closing price at the expiration of the contract on the April 30 price for the November Maine potato future, 1953–1968[a]

Intercept	Slope	$\bar{r}^2$
−2.36 (2.54)	2.06 (1.12)	.14

[a] All data are in dollars per hundredweight. Numbers in parentheses are standard errors.

What then is the explanation for the potato results reported in the article? The answer lies in the data, where we find that the year 1952 was marked by the removal of price controls and exceptionally large price movements. Recalculation of the regression after deleting the observation for 1952 produces the estimates shown in Table 1. These estimates are well within the range that might be expected if the true regression coefficient were unity and the true intercept were zero. Consequently there is no reason to conclude that the forecasting relationship for potatoes is different from that for other commodities in any fundamental sense.[4]

In summary, it appears that the contrast between the continuous inventory commodity futures markets and noninventory commodity markets has been exaggerated by Tomek and Gray. The differences observed between corn and soybeans price movements and potato price movements are due partly to the presence of government price supports for corn and soybeans and partly to an anomaly in the data for potatoes.

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[4] The $\bar{r}^2$ for potatoes here is small. The possibility remains that the magnitudes of such correlations could be a useful criterion for comparing futures markets. However, some means for taking into account other correlated variables, such as support prices, would be required before such comparisons would be meaningful.

Reference

[1] TOMEK, WILLIAM G., AND ROGER W. GRAY, "Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles," *Am. J. Agr. Econ.* 52:372–380, Aug. 1970.

TEMPORAL RELATIONSHIPS AMONG FUTURES PRICES: REPLY

Heifner states that we "exaggerate" the contrast between continuous and discontinuous inventory futures markets and that the differences observed "are due partly to the presence of government price supports for corn and soybeans and partly to an anomaly in the data for potatoes." This reply reviews briefly the conceptual basis of the contrast, clarifies the empirical questions raised by Heifner, and then reaffirms the policy implications of the contrast.

We are not unaware of the price support programs in the United States, but their existence need not obscure the central point of our paper. Changing expectations are, of course, reflected in changes in the constellation of prices, and our article is quite clear on this point [3, p. 375]. In this context, however, commodities with inventories have an advantage over those with discontinuous inventories (whether or not price support programs exist) in the formulation of expectations. Moreover, continuous inventories permit adjustments, to some extent, to changing expectations about supply-demand conditions for the new crop.[1]

Perhaps the best place to begin an attempt to clarify some of the empirical issues is with Figure 4A and 4B in our article [3, p. 377], which evidently do not trouble Mr. Heifner. The underlying logic of our argument is reflected here; and it is surely no exaggeration to say that the May and December corn futures prices are closely related, while the May and November potato futures prices are essentially uncorrelated. These, of course, are daily prices during a month, whereas our analysis stressed year-to-year relationships. But the daily prices indicate that during the month of April estimates of the November potato futures price are independent of the May futures price, whereas estimates of the December corn futures price are strongly dependent upon the current May futures price. This contrast, we repeat, occurs because no potato inventories are carried between crop years, while corn inventories *are* carried and *do* determine the relationship between the May and December futures prices.

The level of free stocks of corn dictates in April of any year whether the May futures price is above or below the December futures price and by how much. In selecting 1969 for our illustration at the time of writing, we happened to choose a year in which the price of the May future in April averaged 2–3 cents higher than the December future because free stocks were relatively tight. Had we selected the prior year, when free stocks were plentiful, the May future would have been shown 6–7 cents below the December future—but still highly correlated, and with prices trending downward instead of upward during April.

Now there is no question but that the price support program for corn, as an example, has a pronounced influence upon the proportion of total stocks that is left free to influence this relationship. In 1963 the corn carryover exceeded 1.3 billion bushels, but less than 80 million bushels were free; whereas in 1967 the carryover was down to 823 million bushels, of which 449 million were free. *But the price support programs have not altered the fact that prices of cash grains and successive futures are linked by inventories* nor the fact that the interplay between inventories and price spreads lends the aspect of self-fulfilling prophecy to grain futures prices which is absent from potato futures prices.

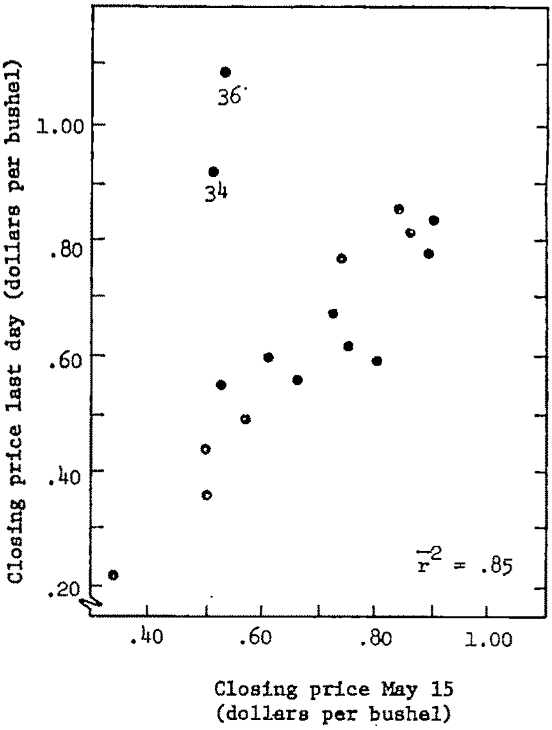


Figure 1. Prices of December corn contract: May 15 and expiration day, 1925–41

Consequently, we find the evidence for the post-World War II period sufficiently persuasive; but evidence from an earlier era (1925–1941), when price supports were not operative, also supports our argument (Figure 1). In this figure the regression line is fitted to all of the observations excepting those shown for 1934 and 1936. The reason for deleting 1934 and 1936 is that these were potato-type years rather than corn-type years, in the sense that the crops were so short that the (small) carryovers could have no substantial influence upon new crop prices.[2] The inventory linkage was overtaxed and virtually broken by these highly abnormal crops, and in this

[1] The constellation of prices for soybeans has been consistently above support levels; i.e., soybean prices have been largely determined by "free market" forces (e.g., see [1]. Now, farmers' planting decisions apparently are influenced by the announced support level [2]; but on April 30 traders have no more information about future soybean production than about potato production, and ex post supply relationships (on which to forecast production) are equally available to traders for all of these crops. In sum, prices for soybeans and potatoes have been largely determined by "free" economic forces and approximately equal (i.e., no) information is available on production; yet the degree of relationship between the April 30 and final closing price differs.

[2] The corn crop typically varied in the range of 2 to 3 billion bushels in the 1925-1941 period. The crop sizes were 1.4 and 1.5 billion bushels in 1934 and 1936, respectively.

Table 1. Estimated linear regressions of the closing prices at the contract expiration on the prices for selected earlier days for the November Maine potato future, 1953–1968[a]

Date	Intercept	Slope	r^2
Feb. 28 (29)	4.64 (2.79)	−.99 (1.19)	.05
April 30[b]	−2.50 (2.54)	2.12 (1.12)	.15
May 15	−3.00 (2.50)	2.32 (1.09)	.24
July 15	.91 (.70)	.62 (.30)	.23
Sept. 15	.31 (.39)	.88 (.17)	.66

[a] All data are in dollars per hundredweight. Numbers in parentheses are standard errors.
[b] This estimate differs slightly from Heifner's (see his Table 1); presumably the data differ somewhat. For 1953–1970 the regression coefficients are essentially unchanged and $r^2 = .21$.

sense, the exceptions prove the rule. It was precisely in the years of extraordinarily small crops, when inventory adjustments were inadequate, that the relationship between the springtime and harvesttime prices was broken. If anything, the relationship is closer (r^2 larger) for this nonprice support period than in recent years.

Heifner goes from floor prices under corn to ceiling prices over potatoes in striving to the conclusion that the differences we observed were due partly to price supports and partly to an anomaly in the potato data. He finds that "the year 1952 was marked by the removal of price controls and exceptionally large price movements." But the facts indicate otherwise. Price ceilings were established on potatoes on January 19, 1952, removed on June 6, 1952, and *never once did the November futures reach or approach the ceilings.* The price of the November future on May 31 before controls were removed was $2.76; on June 15 after controls were removed, $2.74 per hundredweight. It is also well to recall that in 1951, with no ceilings in effect, the November future closed at $2.18 on April 30, $2.00 on June 30, and $3.66 on November 15.[3] Hence, the price ceiling argument is not pertinent.

If this disposes of the alleged cause of the eccentric 1952 observation, it does not dispose of Heifner's

[3] The 1951 and 1952 crop years represent two consecutive years of small potato crops, following discontinuance of price supports with the 1950 crop; and the average U.S. farm price of potatoes in 1952 was the highest since 1919. Thus the cash price for Maine potatoes in November 1952 presumably reflects the prevailing supply-demand conditions for potatoes. Since the 1952 observation does greatly influence the regression coefficients, this perhaps is sufficient justification for dropping that year. Our original justification for including 1952 was that 1951 was the first year of active trading in Maine potatoes but the volume of trading was still quite small. Thus 1952 seemed to be a natural starting point.

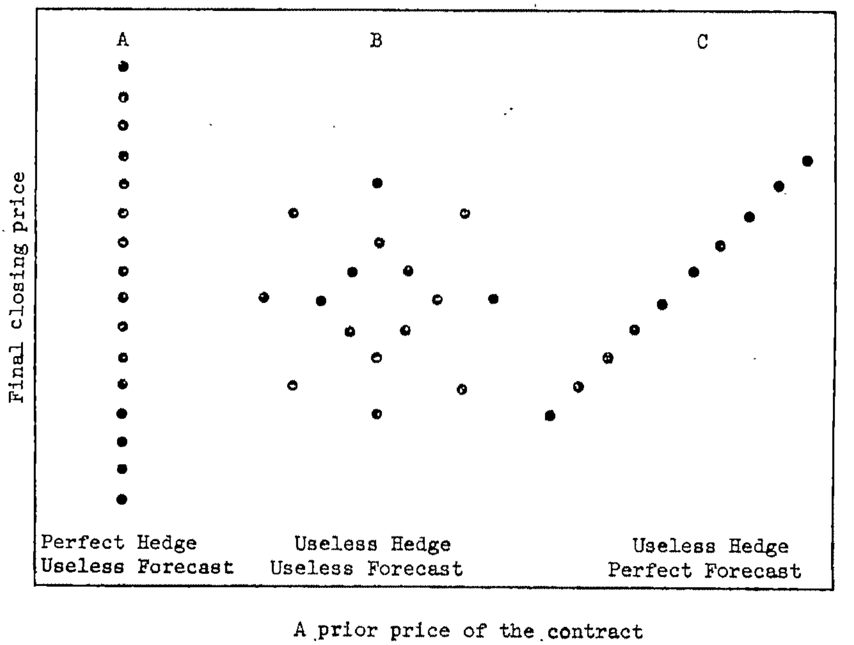
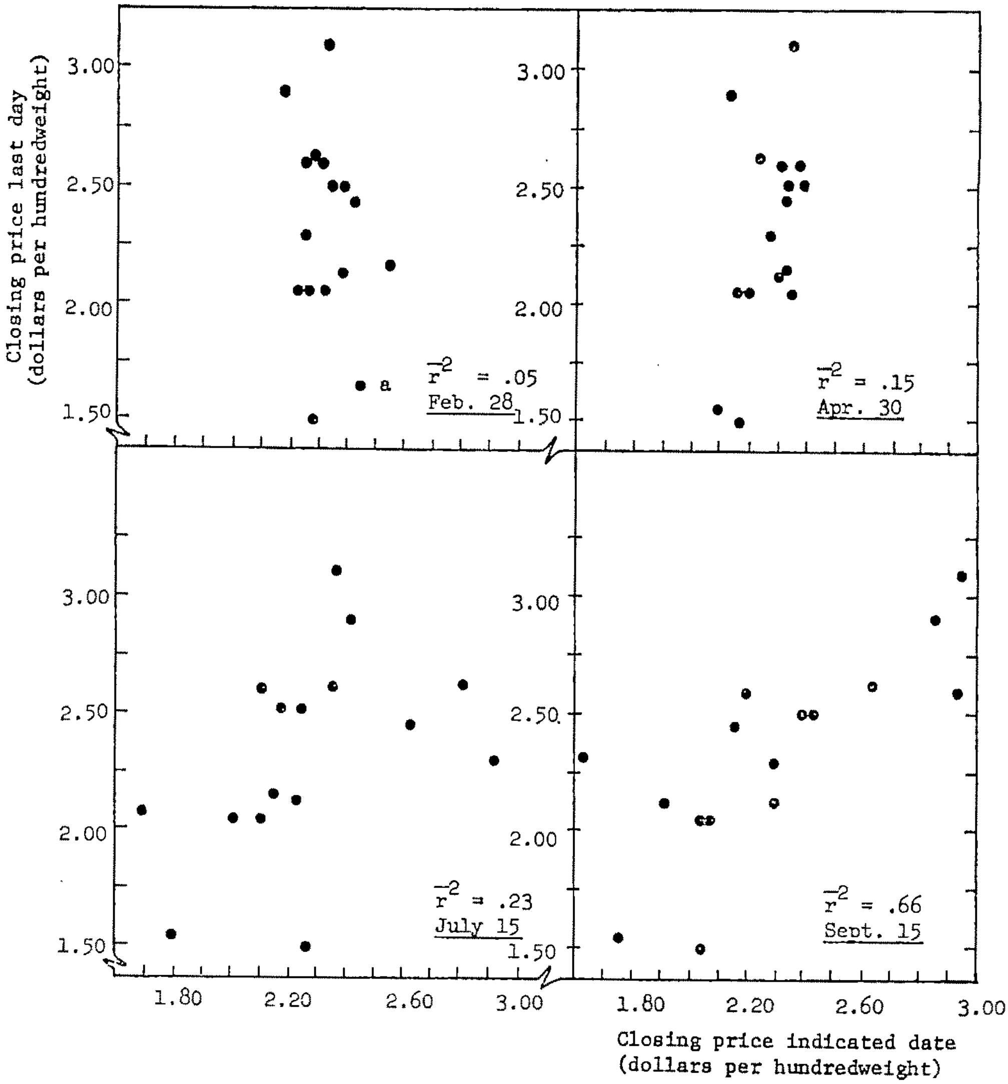


Figure 2. Three hypothetical price relationships between a forecast and realized (final closing) price for a futures contract



a/ In 1953 the February 28 quotation is for the "old" November contract; for the other dates quotations are for the "new" November contract.

Figure 3. Prices of November Maine potato contract: relationships between prices on selected days and prices on expiration date of contract, 1953–1968

misinterpretation of the consequences of deleting this year. A markedly different equation with a markedly lower r^2 (see Table 1) results from the deletion. But Heifner, in stressing the effect of the 1952 observations on the regression coefficients, misses the point that a forecast at the mean value of past observations provides no basis whatsoever for successful speculation, yet provides a means for reducing year-to-year price variability through hedging. A bad fit, no matter what the slope and intercept, provides a bad basis for speculation; but if the variance of the springtime prices also is near zero, a near-perfect basis for hedging exists. If the variance in the springtime values equals the variance of the realized prices, routine hedging will be useless for reducing annual price variability.[4]

[4] Heifner criticizes the policy implications drawn from the contrasting variance ratios. Two points need to be made in rebuttal. First, economists have recommended routine hedging of production decisions by farmers as an *alternative* stabilization policy to price support programs. Thus, Heifner's comments in footnote 2 about hedging strategies with price supports is irrelevant to the conclusions drawn in our article. Second, the contrasting variances do indeed imply differing levels of stability in response to routine hedging programs, and the reader can easily demonstrate this to his own satisfaction with examples using the available data.

Limiting the consideration of hedging to its role in reducing the year-to-year variability in price (as we did), the relevant relationship between hedging and forecasting is depicted in Figure 2. In part A the observations of the springtime price of the post-harvest future all fall on the mean value of the final price; this makes for the perfect hedge (in the above sense), but of course the forecasts are useless and provide no basis for successful speculation. In B the observations are uncorrelated and the variances of "forecast" and "actual" values are identical; this provides no basis for hedging and also yields a worthless forecast. In C the forecasts are perfect but provide no basis for hedging (again, in the limited sense under consideration). In sum, our argument is that in the spring November potato futures will behave approximately as in A, approaching C as the contract expiration is approached. Lacking the inventory linkage, the market reflects the mean November price until crop information emerges upon which to base better forecasts. As such information emerges, the variance of the forecasts will widen; and if early information is superseded by better information, the midseason (say, July 15) estimates may approach the pattern shown in B before finally resolving into the C pattern late in the season.

We next show, in Figure 3, the succession of actual observations for potatoes for selected dates during each year 1953–1968 (omitting 1952). The February 28 (or 29) observations, as well as examination of those for May 15 (not shown), confirm the impression conveyed by the April 30 observations, namely, that these tend to cluster about the mean value vertically. The results for selected dates (during the years selected by Heifner) are shown in our Table 1. The small $\bar{r}^2$ of the April 30 equation is emphasized by comparison with the February 28 equation; what is obvious is that the early season price estimates are nearly the same every year.[5]

These early season estimates for Maine potatoes are apparently based upon the *mean* of the November price; the April 30 price forecasts do not differ significantly from the forecast that the November (expiration) price will always fall at the mean value.[6] Yet the difference in variances between April 30 and November closing prices is great. Thus, they provide near perfect-hedges and near-useless forecasts. On July 15 the forecasts are also poor, but as the variances of the two series now approach equality July 15 provides a poor hedging date (in the sense of reducing year-to-year variability). Finally, on September 15 the forecasts are good but the hedge would be poor, as the variances of the September and realized prices are nearly the same.

By the same token, we have proposed that the corn estimate, for example, would closely resemble Figure 2C in the spring (e.g., Figure 1) and therefore could improve less throughout the season. Commodities with continuous inventories have significant additional information in the spring. Perhaps these scatter diagrams should have been shown in our original article. In any event, we trust this makes clear that the contrast was not exaggerated and that it was not due to price supports or the removal of price ceilings. The springtime estimates of the fall prices for corn or soybeans display essentially the same year-to-year variability as the final estimates, price supports or no price supports. The springtime estimates of fall potato prices display much lower year-to-year variability than the final estimates, 1952 observation or no 1952 observation.

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[5] For the 18 years, 1953–1970, the ratio of the variance of the closing price on the expiration day of the November future to the closing price of the same future on April 30 is 17.2.

[6] The average difference between the April 30 price and the November expiration price for potatoes (in absolute terms) is 30.8 cents; the analogous difference between the mean November price and the observed expiration prices is 34.1 cents. The difference in these differences (3.3 cents) is not significantly different from zero. That is to say, the April 30 price of the November future is not a significantly better forecaster of the November price than the mean of past November prices.

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[2] HOUCK, JAMES P., AND ABRAHAM SUBOTNIK, "The U.S. Supply of Soybeans: Regional Acreage Functions," *Agr. Econ. Res.* 21:99–108, Oct. 1969.

[3] TOMEK, WILLIAM G. AND ROGER W. GRAY, "Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles," *Am. J. Ag. Econ.* 52:372–380, Aug. 1970.

ECONOMETRICIANS AND THE DATA GAP: REJOINDER

In submitting my original comment [1] on the title topic, I felt that the subject was an important one which deserved widespread discussion. Accordingly, I worked on that comment, off and on, for a year and a half before submitting it to the then newly appointed Editor. In my letter of transmittal,

I said that "it is not ordinarily possible to find wrong conclusions in an article and then go back and prove that these wrong conclusions have resulted from faulty data. In the usual case, this is just out of the question." And I added that "the burden of proof should be on the authors of these mathematical concoctions," not on their critics.

This letter ended as follows: "Frankly, I would like to see replies to my comment from other prominent agricultural econometricians, not just from the two authors whose article I have criticized. This, however, is your prerogative." The Editor did not accept the suggestion, and a reply [3] was obtained only from the authors. This proved to be question-begging and issue-dodging, which was perhaps to be expected, but it was also a bit self-serving in that an attempt was made to pass the buck back to ERS.

The Editor felt that publication of this initial exchange would bring in so many other comments and criticisms, on one side or the other, that "our problem will be one of rationing rather than soliciting additional responses." Since more than two years have elapsed, with only one comment [2] published, the Editor's statement can now be categorized along with all our other bum forecasts. The conclusion seems inescapable that most members of our profession do not really care very much whether the newer techniques are properly used or not.

The one comment received [2] was a mild and reasonable one which attempted to differentiate between my "generalizations," *not yet refuted by anyone*, and my specific criticisms of the original article, which are *also not yet refuted by anyone*. The comment concluded as follows: "Up to now, the exchange has been less than straightforward and, consequently, disappointing" [2, p. 680]. My agreement was complete.

Next to appear was another reply [4]—to the one comment received. It blandly denied any wrongdoing, without answering any arguments. It asserted, both gratuitously and falsely, that my "generalizations" are "purely one man's opinion." It again denied what I have been told is the case, namely, that strong and early warning was given, orally, as to the unsatisfactory character of the data. It denied *a posteriori* fishing by describing procedures that *constitute a posteriori* fishing. It made another vague reference to an obscure bulletin as providing justification not included in the Journal article. And it implicitly praised its own brevity in an obvious attempt to shove the whole thing permanently under the rug.

Needless to say, this exchange remains as "disappointing" as it has always been. And if members of our profession have nothing further to contribute, the outlook—for resolving this controversy, for solving some of our important problems, and for the future of our profession—is bleak indeed.

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OUR CHANGING COVER: IN EXPLANATION

With volume 52 the color and design of our JOURNAL cover reflected Mrs. Revzan's taste and considered choice. Not so with volume 53: The latest changes in color and texture reflect commercial necessity imposed by the paper manufacturer.

—Ed.

Reviews

Bhuleshkar, Ashok V., ed., *Indian Economic Thought and Development*, Jawaharlal Nehru Memorial Volume, London, C. Hurst, 1969, 445 pp. (65 s)

This book is a collection of papers covering such diverse topics as Nehru's brand of socialism, an evaluation of India's economic performance over the first three five-year plan periods, a comparison of Indian and Chinese performance, and a cursory examination of large numbers of theories and policies in relation to development.

If viewed in perspective, namely, that the particular ideology highlighted in the book is not universally accepted by India's theoreticians or practical politicians, the Foreword by Lord Mountbatten, the Introduction by Welingkar, and the three contributions by Mehta, Dantwala, and Dhavamony on Indian economic thought are interesting papers for the student of India's brand of socialism. What Nehru meant when he declared that "socialism is something even more than an economic doctrine, it is a philosophy of life and as such appeals to me," is given an interesting interpretation by Welingkar in the introduction: "He [Nehru] thought it [socialism] was capable of furnishing answers to several questions that troubled his mind. For instance, there are several social evils which are attributed to 'original sin' in Hindu philosophy and which were based on a belief that human destiny is unalterable, a belief which interfered with any rational or scientific view of life. Nehru thought that, in sharp contrast to this, Marxism embodied a scientific approach to the solution of several urgent issues in the nation's economic and political life."

Among the papers on theories and policies relevant to development, the most outstanding and original contribution is contained in I. M. D. Little's paper, "Public Sector Selection in Relation to Indian Development." In my view, if the book contained nothing but the Little paper, it would have been worth publishing. For the serious student of cost-benefit analysis and criteria for project selection who is familiar with Little's recent comprehensive statement of what has become known as the Little-Mirrlees method [1], the paper provides a valuable historical perspective into the development of Little's thoughts. He basically makes a strong argument for the case that a developing country must give judicious attention to the selection of what to produce and what to import in opposition to those who would make us believe that consumption targets are prima facie evidence for the justification of projects. While Little has made several refinements on the basic ideas contained in this early paper in recent years, it still contains the best exposition of his thoughts on the subject.

Most of the papers in Part II, Agriculture and Development, belong unfortunately to the category of papers in this collection not worthy of a busy reader's time. Many contain a curious mixture of ideological argumentation and empirical analysis, neither of which appears to be current to an understanding of what is happening in India today. Practically all are restricted to describing and interpreting events prior to 1965. The performance and problems of Indian agriculture have since been importantly affected by years of unusually severe and prolonged drought and more recently by the green revolution.

Among the papers in Part IV, Monetary Policy and Economic Development, and Part V, Other Allied Topics in Relation to Development, the more outstanding, although also partially outdated, are those by Bhuleshkar, "Devaluation of the Indian Rupee: A Step in the Right Direction"; by W. B. Reddaway, "The Importance of External Assistance and Self-Help in Indian Development"; and by Ursula K. Hicks, "Educational Expansion in Low Income Countries with Special Reference to India."

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International Bank for Reconstruction and Development

Reference

[1] Little, Ian M. D., and James A. Mirrlees, *Social Cost-Benefit Analysis*, Vol. 2, OECD Manual of Industrial Project Analysis in Developing Countries, Organization for Economic Cooperation and Development, Paris, 1969.

Bressler, Raymond G., Jr., and Richard A. King, *Markets, Prices, and Interregional Trade*, New York, John Wiley & Sons, Inc., 1970, xviii + 426 pp. ($13.95)

This is a good book; it is a worthy valedictory from the late Professor Bressler. The textbook that he and

Professor King present to us is an example of that complementarity between research and teaching that many of us seek. Concerned as it is with applied price theory in a spatial setting, the work is interwoven with the results of two decades of research (by the authors and others) on problems of pricing in spatial markets and interregional competition. Indeed, the book can be regarded as a logical outgrowth of this research program.

There are five parts. Parts I-III, or possibly IV, are intended for undergraduates; parts IV and V for graduates. Part I opens with a brief history of U. S. economic development and then describes the U. S. economy as it now exists. The authors' intention here is to place the concepts of regional specialization and interregional trade in their historical context: These are not merely abstractions of economic theory; they have in fact occurred.

Part II develops the theory of price determination in a spatial market. Examples are drawn from research, and the use of transportation and reactive programming models are illustrated by sample problems. The figures in this part of the book are especially well done, with many maps and blueprint-style drawings showing both cross-sectional and plan views of three-dimensional relationships. These should prove very useful to students.

The relationships of time and product form with market price are taken up in part III. The exposition is presented from the point of view of a perfectly competitive firm with perfect knowledge of current alternatives and future events. The relationship of price with time is thus reduced to a matter of storage costs. The authors promise (on p. 211) to reconsider their assumption of perfect foreknowledge but do not seem to have done so. Because uncertainty about the future is practically inherent in economic events, the treatment of time seems inadequate.

The interactions of time, form, and space in determining market price are illustrated by seasonal fluctuations in milk production and the resultant changes in fluid milk, cream, and manufacturing milk prices and production zones. The subjects of price discrimination and nonprice factors affecting markets are also taken up in part III. Students will undoubtedly be pleased with the account of Rhode Island's "Pink Milk Caper," included in the discussion of nonprice factors.

Parts IV and V present an evolving picture of the theory of trade and regional specialization together with, in part V, a review of methodological approaches to research in this area. Prior knowledge of operations research techniques is presumed, for much of the exposition is in linear programming terms. Part IV starts with the classic Edgeworth box analysis of the exchange of stocks between two individuals or regions. The analysis is gradually generalized to allow supply from production rather than stocks and investigates the implications of differential production functions for regional specialization and trade. The question of land use is taken up in part V, demonstrating the law of comparative advantage with respect to land and its resultant implications for specialized land use and interregional trade. As indicated, the main thrust of part V lies in its discussion of methodological approaches to problems of location analysis and spatial equilibrium research.

If the book has a serious shortcoming, it is the short shrift given the theory of demand. This is perhaps not too serious in the undergraduate portion, where the focus is on the perfectly competitive firm and demand can be taken as given. It is less satisfactory in the graduate portion, where the focus is on regions. The exposition of trade theory in part IV is prefaced by a brief discussion of the theory of consumers' choice, but nothing is said about the effect of income change. Demand functions containing income terms are encountered in part V as specifications in a general equilibrium model, but nothing is said about what effect they might have on the functions or on model solutions. The terms "income effect" and "income elasticity" apparently never appear in the book.

Of course no book can cover everything, and the excellent treatment of spatial economics that we are afforded here more than makes up for the omissions. Students using this text should be able to get a thorough grounding in the principles of spatial economics, a topic that has been neglected in most economics texts but is vital to an understanding of many aspects of agricultural production and marketing.

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Duckham, A. N., and C. B. Masefield, *Farming Systems of the World*, New York, Praeger Publishers, 1970, XVIII + 542 pp. ($21.50)

An agriculturist is a kind of generalist with practical leanings who is now rare in the United States. It is therefore refreshing to find a book by two English agriculturists on the subject of comparative systems of agriculture. This one is built on the solid foundation of 13 years of lectures at the University of Reading, England, and first-hand experience in the countries discussed. The senior author, A. N. Duckham, is known to many older American agricultural economists as an engaging person who served as British agricultural attache in the United States some 20 years ago. The other author, G. B. Masefield, was for many years in the British Colonial Agriculture Service, mainly in the tropics.

The authors' objectives, as indicated in their introduction, were three: (1) to produce a textbook on comparative agriculture for university use; (2) to provide a reference work for agriculturists, researchers, and administrators; and (3) to attempt, for temperate countries, to construct models poten-

tially capable of quantification that would explain location, input intensity, and food output of farming systems.

They indicate (cryptically) that they hope to bridge the gaps between tropical agriculturists, temperate agriculturists, and economists. This seems to suspend economists in a limbo between temperature zones, but this is not what they mean. What they have really done is to provide a useful reference book with a broad coverage on a once-over-lightly basis of what used to be termed physical and economic geography and what, with some important additions, is currently glorified as ecology. They do not attempt to cover the whole world but instead have a representative selection of countries (other than the communist nations for which good information is scanty) in both the temperate and tropical zones.

An ingenious "transect" device is used to provide a running profile of farms and farming systems as one passes across each country in one or more straight lines. Detailed information is presented for 42 sample farms and for a much larger number of farming systems around the world. Tables, charts, and pictures are used in abundance.

Americans will question some of what is said about the United States. For example, the statements about trends toward large-scale farms and toward contract farming seem overdrawn.

British terms will also need translation for some readers. Not everyone will recognize that lucerne, fodder, lorry, sward, pulses, groundnuts, and influents mean simply alfalfa, concentrate feeds, truck, grass, beans and peas, peanuts, and causal factors. But these are relatively small matters. A more serious fault is that some of the many excellent charts and tables are too full of information and are difficult to unravel.

Agricultural economists as well as agricultural ecologists and administrators will find this a useful reference on comparative systems of agriculture and a convenient place to get first impressions of the agriculture of the selected temperate and tropical countries. It will also be useful for supplementary reading in university courses. The attempt to suggest a way to build models for potential programming is interesting but less successful because of the complexity of the problem.

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Grunwald, Joseph, and Philip Musgrove, *Natural Resources in Latin American Development*, Baltimore, The Johns Hopkins Press, 1969, xvii + 493 pp. ($20.00)

One of the serious problems of Latin American development policy is the role of primary products. On the one hand, following the leadership of Paul Prebisch, interest has been centered on developing manufactures. On the other, progress has been extremely limited in exporting manufactures, so that export success to date is almost synonymous with primary products exports. Also, success in obtaining increases in production and exports of primary products may be useful in development of manufacturing capacity and the essential imports of raw materials and component parts.

The purpose of the book is an assessment of the contribution of the natural resource sector to the economic development of Latin America. For four centuries primary products have dominated production and exports of the region, with raw materials constituting 95 percent of exports until the last decade. Nevertheless, the transformation of the economy that is represented by industrialization has made considerable progress since 1930, when the worldwide depression and the great fall in demand for raw materials spurred diversification. Between 1929 and 1960, the combined industrial output in the five major countries grew twice as fast as total gross domestic product. Growth was especially marked between 1929 and 1950, although there was little or no increase of exports by most countries as import substitution was emphasized. Throughout the period, there has been little development of manufacturing for export.

The next phase of Latin American development, the authors say, must include such a growth in manufacturing exports or the integration of the industrial and export sectors to a greater degree than at present. Perhaps, this may be achieved through the economic integration of the region aided by evolution of the present Latin American Free Trade Area (LAFTA) and other trading groups of states. The resource sector may ultimately yield to industry its predominant role in earning foreign exchange. The result would be an economy in which the primary sector had ceased to be a sector apart and had become fully integrated with the rest of the Latin American economy.

Yet the shift from dependence on raw materials for foreign exchange earnings faces tremendous difficulties. Latin American industrialization has not yet proceeded far enough to become independent of foreign supplies of machinery, equipment, replacement parts, and components. Accelerated industrialization will therefore require increased imports of the needed materials for domestic production despite the declining needs for imports of finished consumer goods. In addition, Latin American industrial products are not yet able to compete effectively in the world market. Without receiving preferential treatment in developed country markets, manufactured exports cannot be relied upon in the foreseeable future to earn the foreign exchange needed for economic development. The role of foreign capital is being limited, partly because of the memory of past abuses and partly because of growing national concern about foreign control.

The problems with ownership of minerals resources are especially troublesome. They are complicated by

the exhaustibility problem, i.e., the fear that resources may be exploited mostly for the benefit of foreigners.

Agriculture is less troubled by foreign control, despite conspicuous exceptions. And the danger of exhaustion of resources is minimal. The chief problem is with the supply of temperate zone crops where the expansion of domestic demand has been greatest. Most of the increase in agricultural output in the past has been derived from an expansion in area, with limited increase in yields. In most circumstances such expansion provides little increase in output per person employed and little or no reduction in costs. The good, readily accessible land is already being used and the vast, untouched hinterlands may not be of immediate value for agriculture under the present state of technology.

"Basic changes in the structure of production will be necessary before significant progress in agriculture is possible. This sector has been the weakest link in the chain of Latin American development, and in many countries agricultural production has lagged seriously behind population growth in the post World War II period" (p. 40).

The book begins with an historical survey of the development of the region, with emphasis upon the effect of the shrinkage in world markets for primary products during the great depression and World War II upon the decision and need to industrialize. Then a chapter on "Major Issues and Problems" is an excellent analysis of the many-sided relation of resource industries to economic development and progress, recounting Latin America's experience and prospects. The responsibility of developed countries in lowering barriers to manufacturing imports from Latin America is essential for the transformation and industrial development of the region. There follows a statistical summary, by products, of resource industries and a long appendix, by countries, that is conveniently arranged for reference. The final section, comprising two-thirds of the book, has separate chapters on each of the 15 major commodities produced by the resource industries of the region. The products include six minerals, seven farm products, forestry, and fisheries. The farm products are coffee, cocoa, sugar, bananas, wheat, beef, and cotton.

The work is intended for use in university courses as well as for development economists who need an introduction to the various countries and the specific products of the natural resources sector. Its incisive treatment and convenient arrangement will make the book valuable to each group.

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Hadwiger, Don F., *Federal Wheat Commodity Programs,* Ames, The Iowa State University Press, 1970, xi + 407 pp. ($10.50)

The stated objective of the author is to present a history of federal policy relating to wheat in the 20th century. He seeks to answer three questions: Where did the policy come from? What was the policy? What were its effects? Hadwiger attempts to do this by interweaving political and economic analyses of wheat policy. The approach is first to review in sweeping summary form domestic policies from pre-World War I to the end of the Freeman regime (chapter 2). Next the reader is treated to a more lengthy review of export policies over the same period (chapter 3). Thus, after the first 80 pages, the reader has been the gamut from 1914 to 1968 twice by means of a somewhat artificial attempt to separate domestic from export policy. At this point the reader might anticipate similar 60-year sweeps on other more detailed aspects of policy. But such is not to be. Hadwiger then begins to treat chronologically the two price schemes of the 1920's (chapter 4), the Agricultural Marketing Act of 1929 (chapter 5), and the 1933–1935 life of the first AAA (chapter 6). Then we jump to the 1938 AAA in chapter 7, and the reader who knows something about wheat policy wonders what happened to the Soil Conservation and Domestic Allotment Act of 1936. Chapter 8 next jumps to the Benson period, 1953–1960, and one wonders this time what happened to postwar policy, the Brannan Plan, and the Agricultural Acts of 1948 and 1949. Then, as if the author also began to wonder, these turn up in a 10-page insert in the middle of chapter 8. In chapter 9 the author leads us to soil conservation measures, which begin with the missing Soils Conservation and Domestic Allotment Act and finishes with the soil bank legislation of 1956. Hadwiger then treats the Freeman programs of the 1960's in considerable detail and with much insight (chapter 10). The remaining chapters deal with stocks and the CCC (chapter 11), distribution of producer benefits (chapter 12), food aid (chapter 13), and some conclusions.

After having read the book, the reviewer wondered whether a different organizational format might not have made the book more readable. Hadwiger has done a scholarly job of research by including, somewhere in the book, a great deal of well-documented information about wheat policy. His prose is also very readable; but every so often one pauses to ask, "Why am I here and where am I going?" Perhaps the organizational format is more confusing to one who knows a little about wheat policy than to one who knows nothing. But this reviewer certainly would have preferred a chronological history. American farm policy, and wheat policy in particular, evolved as a product of ever-changing times, with the methods of approach very much a product of the times and interrelationships with other commodities.

The approach of intertwining political and economic factors into a politico-economic study of policy has much merit. Particularly in dealing with the Freeman area, Hadwiger demonstrates that the interaction of farm groups, Congress, and the Executive Branch generally yields compromises that

don't look much like what any particular group wanted. Also emerging are the different effects of doctrinaire (Benson) versus pragmatic (Freeman) approaches to wheat policy. These differences occur both with respect to the conceptual approach and the administration of programs. Clearly, the political characteristics of the men involved interact, sometimes in strange ways, with the economic issues involved.

Hadwiger's book is well written, and it contains a wealth of information on wheat policy never before assembled in one book. Its weakness is that unless one knows a great deal about wheat policy the information is difficult to find. To the uninitiated reader, the book unfortunately may be more confusing than enlightening.

ALEX F. MCCALLA
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Hartman, L. M., and Don Seastone, *Water Transfers: Economic Efficiency and Alternative Institutions*, Baltimore, The Johns Hopkins Press for Resources for the Future, 1970, xiii + 127 pp. ($5.75)

This little book has more in it than its size would indicate. It is a simple and concise presentation of the conceptual structure for analysis of the economics of water transfer and the economic changes induced by alteration of the resource base in any basic economic sector. The presentation is largely verbal, simply written, and eschews symbolic presentation except at a few points where symbolization simplifies rather than clouds understanding. It avoid mathematical formalization entirely except in some conceptual explanations of empirical analyses.

Its concise presentation, however, makes rapid reading impossible. With the exceptions of Chapter IV–VI, which are empirical descriptions of the structure and behavior of water organizations in Colorado and New Mexico, not only is every paragraph and every sentence important but every phrase within each sentence, often every word, is essential to the argument and must be read and grasped by the reader in order to follow the logic of the argument.

Chapter I (5 pages) sets the problem in the relative immobility of water resources as between uses and areas of use stemming from the physical interdependencies of water uses which preclude simple property-right systems for water. The authors formulate the conceptual structure and to a lesser degree test it empirically, for analyzing the economic efficiency with which the institutional system peculiar to water affects the allocation of water among uses and areas. Two basic types of institutions are analyzed "in terms of the efficiency of their allocative function: the law and its implementing procedure; and the rules governing the internal and external operation of various kinds of collectives."

They begin, in Chapter II (9 pages), by considering "the allocation of water within a single basin from an atomistic decision-making point of view." The question posed "concerns the legal procedures for transfer of ownership rights and how these procedures operate in an efficiency sense."

The problem emerges from the technological externalities stemming from return flow to the stream of diverted water that is not consumptively used which is then available for re-use by others "below" in the system. A technological external diseconomy arises when some or all of one or more upstream users' water is transferred out of part or all of the system, thus reducing the volume or quality, or both, of the return flows available to all users below the previous diversion points of the transferred waters. The aggregate MVP of a unit of upstream diversion is made up of the MVP generated directly in that diversion *plus* the sum of all MVP's generated in each successive use of the progressively diminishing return flows as the unconsumed portion of the initial diversion moves down through the system. Present western water laws recognize this interrelatedness in water supplies by protecting return flow users' rights when a transfer occurs that changes point of diversion or type of use by permitting transfer only of that portion of the right that has historically been consumptively used, permitting the historic return flow to continue to flow undisturbed into the system.

Chapter III (11 pages plus 6 pages of appendix) then examines the transfer process under the appropriation doctrine of water rights as it operates in Colorado and New Mexico, assessing its performance against the criterion of economic efficiency. The authors find that "obstacles to transfers do not inhere so much in existing laws as in the uncertainties associated with the physical hydrologic system and the effects accompanying the transaction and that these uncertainties are affected by the procedures through which factual evidence is generated and evaluated." Hence, not only is market-like transfer discouraged by restriction of the transferable right to the historic consumptive portion thereof but transfer is further discouraged by the uncertainties surrounding how the historic consumptive use fraction will be determined and hence how big it may be held to be.

Chapters IV–VI (28 pages, including 3 pages of appendices) begin by pointing out that transferability of water, which appears to be severely restrained by water rights law and the administrative and judicial processes established to oversee it, is, particularly within a specified use such as agriculture, "more responsive than an analysis of the judicial process of water transfer in Colorado suggests" (as analyzed in the preceding Chapter III). The authors find the institutional circumstance in Colorado that relaxes this apparent restraining influence of water law and its administration in "the development of a set of water organizations, one result of which has been to circumvent some of the rigidities imposed by legal restraint." They then describe the organization

and behavior of mutual ditch companies in Colorado (Chapter IV), the Northern Colorado Water Conservancy District (Chapter V), and the Southeastern Colorado Water Conservancy District (Chapter VI) relative to the apparent loosening of the legal restraints on transfer.

These chapters are brief but cogent descriptions of the differing organizational powers and internal policies of these districts affecting the degree to which they relax in practice the apparently built-in legal restraints on water transfer. In the concluding chapter (IX), relative to the analysis of these organizations, the authors point out that the existence of these districts in Colorado, each having different internal rules affecting internal allocations of water, "suggests that organizations with desirable economic features do not spontaneously come into existence." The contrast between them "points up the need for informed guidance in district formation, i.e., in institutional design." However, they hypothesize that "in situations where some people are made better off and some worse off from a rule change, the change may not take place because of uncertainties in predicting consequences and also because there is no procedure for compensating the losers." The "uncertainties in predicting consequences" derive from our lack of knowledge about the behavior of the hydrologic system; the lack of a "procedure for compensating the losers" refers us back to water law as the source of that difficulty.

A relevant criticism here is that one cannot generalize to all appropriation doctrine states the authors' analysis of the relaxing role of water organizations in Colorado. In Arizona, for example, no such organizations having such relaxing powers exist. In fact, in Arizona, the law as well as Federal reclamation policy severely restrains if it doesn't wholly prevent transferability, not only of historic "direct flow" rights but also of "stored and developed" water rights which are nominally held in their aggregate by the district.

Furthermore, the Hartman-Seastone treatment of technical externalities and organizational powers relative to water transferability relates explicitly only to stream or stream-like *flowing* water. In states like Arizona and others where groundwater of a stock resource type is an important element in the water use picture, frequently exploited in conjunction with surface flows, the analytical problem, though similar in many ways to stream-flow analysis, exhibits complexities and differences in law and water administration sufficient to make it almost a different problem. In these situations the return-flow, hydrologic-system knowledge is far less well-known and more complex, and the institutional structure for coping with it is generally far less well-defined in law and in organizational existence and operating policy. Thus, there is another hazard in generalizing this study's Colorado findings to other situations in other states.

Chapters VII and VIII shift the discussion and analysis to a different problem altogether, although it may be related to the technical externality problem treated in preceding chapters. In the preceding chapters the analysis considers only the economics of the *direct* effects on water users of a water transfer as the transfer and its effects might be modified by organizational behavior. In Chapters VII and VIII, the economic or "market" interdependencies (externalities) that flow *indirectly* from the initiating direct effects on water-using firms are considered.

Chapter VII (22 pages, including 4 pages of appendix) sets up the conceptual structure for the analysis of market externality effects stemming from the direct water-user consequences of water transfers. The authors conceptualize a three-region model that encompasses the national economy: (A) the water "exporting" area (region), (B) the water "importing" area (region), and (C) the "rest of the world" (national economy). They then assume a one-way transfer of an incremental quantity of water from area (region) A to area (region) B and hypothesize the induced flows of productive (nonwater) factors—labor and capital funds and facilities—between and among these areas (regions). In the rest of the chapter they conceptualize the model appropriate for analysis of the induced economic effects of water transfer under conditions that deviate from the idealized competitive model.

They find four different kinds of interdependencies and proceed to identify them specifically and to analyze their effects: "(1) a household income consumption multiplier effect; (2) a business multiplier effect on suppliers of production inputs and related sectors; (3) a cost-increasing effect on firms processing output from the water-using activity; and (4) an accumulative effect on the public sector through loss of tax revenues and reduction in use of public facilities." They then proceed to conceptualize each of these in turn.

They conclude that "consideration of income interdependency effects can be most expeditiously taken into account in the planning stages when the agency is deciding on alternative sources of supply ... the planning group can calculate the income effects of buying water from existing uses to compare with that of bringing in more distant supply sources. In arriving at a cost for buying out an existing use, the rate of withdrawal as it affects labor and capital mobility and the planning time necessary for recovery of capital expenditures is of critical importance."

Chapter VIII (25 pages including 10 pages of appendix) carries through an empirical estimate of negative income effects from water transfer from the standpoint of the exporting or selling region. It illustrates the process of giving empirical content to the conceptual formulation of the preceding chapter. The Imperial Valley in Southern California is the case study chosen because of its proximity to the rapidly growing urban population of the Southern

California coast and the availability of pertinent data.

As one would expect, the empirical study is not as neat and tidy nor as sharp and elegant as the conceptual analyses of preceding chapters. Though the analysis is phrased in terms of the agricultural economy of the Imperial Valley and though some of the quantifications used are of empirical origin, Chapter VIII turns out to be in fact but little more than an illustration and explanation of the use of an input-output model to derive relevant multipliers and the use of the multipliers to derive aggregate income effects stemming from an induced exogenous change.

As an illustration, the chapter is all right as far as it goes. The danger is that unwary, biased, or unsophisticated readers may take the chapter's analysis at face value which, if they do, will lead to much mischief concerning interpretation of the social cost of water transfers from already established irrigation areas. Unfortunately, the authors abet such unwary interpretations by saying, "The order of magnitude of the above estimates [$295 per acre-foot] calls into question the desirability of large block withdrawals of water from developed agricultural areas." No such statement is warranted by the analyses given in Chapter VIII or elsewhere in the report. The multipliers from which this water value is derived are restricted to the Imperial Valley (area A of their conceptual model). Without estimates of the orders of magnitude of the value of the transferred water to affected area B (the receiving area) and to area C as well, no such statement is warrantable.

Furthermore, plausible alteration of some of their key assumptions and some of their empirical manipulations, as well as inclusion in the analysis of some elements of their conceptual model left out of their empirical calculations, materially affects the order of magnitude of even their own estimate of the value of the transferred water to area A.

The many questions concerning the analyses of this chapter that must be considered and resolved in order to guard against the dangers of unwary reading and to make it a more adequate empirical estimate of the order of magnitude of the aggregate costs of water transfer require more space than this review affords.

This little book is a simple but excellent presentation of the conceptual structure for economic analysis of water transfers. The empirical descriptions of the structure and performance of water organizations relative to economic efficiency of such transfers are also pertinent and suggestive, although they are by no means the last word on that subject. The illustrative empirical implementation of the model is the work's chief weakness. This reviewer wishes the authors had left it out entirely or had developed it more cogently and completely.

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Idyll, C. P., *The Sea Against Hunger*, New York, Thomas Y. Crowell Company, 1970, xxi + 221 pp. ($7.95)

Most discussions of present and prospective world food problems include only a short passage on the possibilities of expanding the harvest of food from the sea. Those who would like to know more about the subject may be interested in this book, which was written by a marine biologist. It presents a detailed and systematic examination of the various possibilities for increasing the oceans' food production.

The basic premise is that despite the green revolution land farming will continue to have difficulty in providing man's food needs, and alternative food sources are urgently needed. Although the sea presently contributes only a small part of the world food supply, in the range of 1 to 3 percent of total human calory consumption, fish landings have increased rapidly in the last decade. Also, the qualitative contribution is much more impressive than the quantitative one, as fish supplied 13 percent of animal protein for human consumption in 1960, the only year for which an estimate was given. Since the sea covers 71 percent of the earth's surface, and the same basic food production principles apply as on land, its promise as a source of food demands careful investigation.

Aquaculture, or farming the sea, seems a logical step forward in increasing marine food production. However, husbandry of sea animals involves many unknowns and complexities. Technical problems and the management problem caused by unlimited access in national and international waters will preclude efforts in the bulk of the ocean areas and restrict efforts to the limited shallow-water coastal areas. The author feels that most aquacultural development in the near future will involve expensive products for high-income nations rather than food for poor people in developing nations.

Discussed and then rejected as basically infeasible for a variety of reasons are the harvesting of plankton, the use of seaweeds, and the transplantation of useful species into areas where they do not occur naturally.

Some areas of the sea, such as the Atlantic Ocean off the west coast of Africa and the Indian Ocean, could support larger fishing efforts; but many of the most productive areas are already heavily fished. If more men would be willing to eat largely unexploited species such as squids, sharks, and sand lances, these could be harvested as an addition to the food supply. The author is particularly enthusiastic about the potential for using presently undesirable species either in fish protein concentrate, a tasteless, odorless flour which can serve as a protein additive to more familiar human foods such as breads and soups, or in fish meal which is used in animal feeds. The discussion of the possible yield from more intensive

or extensive fishing of the traditional type is clouded by considerable uncertainty about the actual sizes of stocks, future demands for nontraditional products, future changes in harvesting technology, and developments in legal-political arrangements for the use of the sea.

The conclusion is conservative. Although food material is manufactured in the sea in very great quantities, the potential is not likely to be realized because of the numerous biological, social, economic, political and technical barriers. "If we concede imperfection of man and the reality of nature, it is probably realistic to hope that the sea will some day produce 200 to 250 million tons of usable food—four to five times the present yield. To the extent that man becomes more rational in his behavior and that he sharpens his understanding of the complexities of the ocean and his skills in fishing techniques and management, larger harvests will be possible: perhaps 400 million tons without stretching credibility —one billion as a more remote possibility" (p. 203). Thus, although he advocates increased efforts in this area, Idyll does not feel that the sea is likely to offer a significant solution to human food problems.

This is a book written for intelligent laymen. It was interesting to read, and a number of photographs added to its appeal. However, some errors, inconsistencies, and editorial weaknesses were noted. The charts and tables, apparently unmodified in form from the original sources, were not always appropriate and were sometimes located several pages away from the relevant discussion in the text. I was left with the impression that the author gathered statistics from the most convenient sources and did not always further check to determine whether the different statistics were consistent.

There are few comprehensive books on this subject. For a balanced introduction to the full set of considerations relevant to the development of marine fisheries, I recommend that the reader supplement Idyll's book with Christy and Scott's *Common Wealth in Ocean Fisheries* [1], which was previously reviewed in this Journal (50:775–777, Aug. 1968). Christy and Scott give a more thorough discussion of economic, legal, and political issues. Critical aspects of fisheries management are the short-run and long-run economic inefficiency and conservation problems that result from resources being international common property. Idyll does not ignore economic considerations, but, as would be expected from a biologist, his treatment is quite simplistic. He is also obviously a pragmatist who rather resignedly feels that extension of present bilateral and multilateral agreements among nations is about all that can be expected in the way of improved human arrangements for management of marine fisheries. The chief values of Idyll's book are its wealth of insights into the nature of sea animals and its fascinating albeit discouraging compilation of the many problems encountered in attempting to harvest food from the sea.

There is a disturbing postscript to this review. As I write it, the newspapers are reporting that unacceptably high mercury levels have been found in tuna, swordfish, and other fish and shellfish. The full extent of mercury contamination and other types of marine fish pollution is not known, but it may be pervasive. Further studies and explanations are needed and will be forthcoming. To some extent, it is hoped to a small degree only, this book may already be obsolete.

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Reference

[1] CHRISTY, FRANCIS T. JR., AND ANTHONY SCOTT, *The Common Wealth in Ocean Fisheries*, Baltimore, The Johns Hopkins Press for Resources for the Future, Inc., 1965.

Johnson, Glenn L., O. J. Scoville, George K. Dike, and Carl K. Eicher, *Strategies and Recommendations for Nigerian Rural Development, 1969/1985*, Consortium for the Study of Nigerian Rural Development, East Lansing, University of Michigan, 1969, ii + 158 pp. Price unknown. Paper.

This report to the Nigerian Government represents the capstone volume of 45 studies and working papers of some 40 individuals working over a three-year period in a four-university consortium financed by AID. Johnson and Eicher had earlier been the first and second directors (1962–1966) of the AID-financed Economic Development Institute at Enugu, which was primarily concerned with research on agriculture in Eastern Nigeria. This study thus represents the fruit of a large research personnel input and some four to five million dollars.

Nine chapters cover a description of the agriculture sector, trends since 1950, crucial policy issues, alternative agricultural strategies, recommended production campaigns, institutional support, and financial and manpower requirements. Policy measures, output projections, costs, and administrative arrangements are spelled out in admirable detail. The writing is of excellent quality throughout. Each chapter is self-contained and there is a long introductory summary. These features should make the report quite effective as a working manual; they also mean that there is a good deal of repetition for anyone who reads cover to cover.

Chapter 2 provides the most satisfying overview of the Nigerian agricultural economy that this reviewer has encountered. Ecological zones, cultivation regimes, the developmental sequence in land tenure arrangements, the functioning of product and factor markets, and the lagged nature of supply responses

are all described with exactitude and economy. Perhaps the most interesting feature of Nigerian peasant agriculture, and one which receives central attention in the study, is the dichotomy in genetic technology between domestic food crops and primary exports. The latter—palm produce, cocoa, groundnuts, cotton—are based on comparatively high-yielding varieties that have benefited from considerable external borrowing and internal research; the problem here has been the various forms of commodity taxation that have tended to repress Nigeria's comparative advantage and thereby aggregate export volume. On the other hand, the unimproved plant varieties of cassava, yam, millet, maize, and guinea corn result in very high-priced domestic proteins and starches. The authors' principal policy correctives for releasing these constraints on agricultural development include removal of export taxes, biological research, extension, and the discontinuance of unsuccessful public enterprises such as farm settlements and plantations.

As a policy document this report should exert a beneficial influence. Given the propensities of Nigerian policy makers, the case against export taxation cannot be made too often. The persuasive counsels for close regional cooperation in the design and administration of agriculture policy are very much to the point in the face of current trends of autonomy for the twelve states. The emphasis on biological research and extension as against glamorous, large-scale directly productive public enterprise is also a useful counter to the strong political attraction toward the latter. Finally, the report contains a fully worked out program which lends itself to direct implementation.

One can, however, question a few of the authors' specific conclusions. The recommendations to expand production of kenaf and sugar did not consider the much cheaper import alternative. The positive evaluation of latex rubber possibilities made no mention of the unsuccessful project in this area in the mid-1950's. The argument that "investment of land, labor, and capital has been pushed beyond privately profitable margins at prices now paid to farmers" (p. 4) is not completely clear. Marginal product is low but no lower than in the urban sector's unemployment-camouflaging activities of small industry, trade, and personal services. Similarly, with the exception of palm oil, it is difficult to show that substantial repression of any export commodity has actually occurred during the last decade; the danger, though, is a very real one.

The reviewer's major criticism of the consortium project is the comparatively little solid field research that was undertaken. This is perhaps not a gentlemanly issue to raise since it is true of a great many such enterprises in developing countries. Yet, in light of the resources available and the fact that the major obstacle to intelligent analysis of Nigerian agriculture is lack of basic data—number of producers, acres cultivated, input patterns, etc.—I think it is a criticism that needs to be made. As an extreme example, the authors employ a 1963 figure of one million for oil palm producers, citing a "statement by Kilby" (p. 27); the reference was in fact to a casual estimate *en passant* for a quarter of a century earlier (1938)! There are many ways to produce new data—sample surveys, enumerations (the reviewer supervised a complete count of small industry establishments and employment in Eastern Nigeria in three months at a cost of $2,000), analysis of aerial photos, interpolation from other types of data (tax rolls, electoral statistics)—but most of them involve old-fashioned footslogging. While a few of the studies did involve sample surveys of farmers, one almost gets the impression that the four frequently cited doctoral dissertations of Anschel, Thodey, Wells, and Welsch generated more new knowledge than the entire consortium effort. Given the much cheaper cost of doctoral candidates and their greater willingness to suffer the privations entailed in primary data collection, it may well be that such vehicles as the earlier MSU-directed Economic Development Institute, which can mobilize thesis researchers and send them into "the bush," are a more efficient solution than consortia to the problem of developing basic economic knowledge.

PETER KILBY
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Mueller, Willard F., *A Primer on Monopoly and Competition*, New York, Random House, 1970, xii + 203 pp. ($5.95 cloth, $2.50 paper)

This book by the former director of the Federal Trade Commission's Bureau of Economics surveys at an elementary level the current state of industrial organization knowledge and antitrust policy. It covers an impressive expanse of territory in generally lucid fashion, presumably for an audience of economic principles students and the general paperback-reading public. The presentation is largely descriptive, laced with numbers, case studies, and value judgments. Mathematics and diagrams are absent.

Despite his avowed goal of building a broad-based constituency for vigorous pro-competitive policies, Mueller avoids that shrillness which sometimes afflicts those who have spent eight years in the trustbusting halls on Constitution Avenue. Indeed, Mueller's overall prognosis on the current situation is surprisingly sanguine: he finds that "it is effective competition, not monopoly, that is the rule in American industry." Only when he deals with the F.T.C.'s bête noire, alleged predatory pricing, does he lose his analytic cool, making no effort to draw that fine line between merely vigorous and willfully destructive competition.

Mueller's attempt to present a balanced picture of the U. S. industrial sector's structure and performance and the difficulties of addressing a lay audi

ence interact counterproductively on occasion. After marshalling the evidence that production and research scale economies seldom compel high market concentration, Mueller acknowledges that promotional economies may persist even as consumer goods sellers achieve substantial market shares and absolute size. But he fails to bring out clearly the distinction between real and pecuniary economies, and he builds no solid argument that even real promotional economies might be socially disfunctional. Likewise, he observes that profitability is a leading indicator of industry performance and summarizes the research showing profits to be positively correlated with market concentration. But he only *asserts* that supranormal profits imply resource misallocation, without ever showing how or why. If I were Mueller's typical lay reader who patronizes supermarkets and occasionally buys (or aspires to buy) a share of stock or two, I can see how I might be convinced from his analysis that mergers which reduce unit advertising costs, bolster power to secure discriminatory savings passed on in part to consumers through lower end-product prices, and raise profits are a good thing, to be encouraged—not discouraged—by public policy!

Mueller concludes his work with a set of policy recommendations, including more resources for antitrust enforcement agencies, curbs on major new conglomerate mergers, fuller disclosure of corporate divisional operating results, unspecified solutions to the waxing international trade restriction problem, limitations on interlocking directorates and banks' ntervention in nonfinancial corporation decision making, and a maddeningly vague proposal which may or may not call for more structural divestiture action against existing consolidations of market power.

F. M. SCHERER
University of Michigan

Roy, Ewell Paul, *Collective Bargaining in Agriculture*, Danville, Illinois, The Interstate Printers and Publishers, Inc., 1970, 280 pp. ($6.95)

The title and topic of this book continue to engender considerable interest among persons interested in U. S. agriculture. It is, therefore, logical that such a book describing past, present, and future attempts by agricultural producers and farm workers to improve their economic welfare through collective bargaining should be written. Roy treats four broad topics: the scope of bargaining in U. S. agriculture; economic and legal foundations of these activities; operational aspects of bargaining associations; and alternative means of strengthening the bargaining power of farmers and farm workers.

Unfortunately, the author makes several fundamental errors of fact or judgment that detract from the book's quality. Bargaining power is defined synonymously with *economic* power, whereas the former is actually a subset of the latter (along with market power and political power) [1]. "The ability to influence the outcome of the price-making process" (p. 4) may be a result of several factors, without necessarily encompassing or including the bargaining process. The failure to draw this distinction creates confusion in the reader's mind as to the actual source of power under the various programs and types of legislation discussed.

The statement that "one manifestation of the farmers' lack of bargaining power is their declining share of the consumers' food dollar" (p. 1) is invalid. The farmers' share has not declined significantly during the past 15 years; neither is it a useful measure of bargaining power among participants in the food production-marketing system. A concluding remark that "collective bargaining in agriculture will increase in the years ahead . . ." (p. 225) is also a questionable assertion. Similar other omissions and commissions appear throughout the book. While advancing several ambitious legislative acts needed to stabilize the economic power of U. S. agricultural producers, the author ignores the most important determinant of the success of such programs: political acceptability. Marketing boards are discussed as a legislation-created tool for strengthening farmer bargaining; however, the problems recently encountered by marketing boards in Canada and Europe are not mentioned. These examples suggest that marketing boards (and indeed bargaining organizations) without stringent production control provisions are unable to cope with the basic problem facing U. S. agriculture: excess resources devoted to the production of farm products.

The discussions of farm worker bargaining, interspersed with considerations of bargaining over price and other terms of trade for agricultural products (the primary subject of the text), reduce the book's readability. While farm labor issues are cogent, they could have been treated more effectively in a separate section or in another publication. Nevertheless, the comparisons of farmer bargaining associations with labor unions (Table 4–1, pp. 64–70) are both interesting and useful.

Notwithstanding these limitations, the book does contain a substantial quantity of useful information on cooperative bargaining in agriculture. Chapter 5, "Organizing and Financing Bargaining Associations," is a valuable source of information for anyone contemplating the establishment of such an organization. The first two pages of Chapter 13, "Recommendations for Collective Bargaining in Agriculture," include some excellent observations on the economic limitations of farm bargaining in the absence of effective supply control. The book is better suited "as a handbook or reference for farmers, politicians, educators, journalists and others" (one of its two objectives) than "as a text for students of farm policy and collective bargaining" (Preface).

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Reference

[1] GAROIAN, LEON, AND JAMES YOUDE, "Economic Power: Its Role in Increasing Returns to Wheat Producers," in *Problems and Prospects for Farmer Bargaining Power*, proceedings of a Conference on Farmer Bargaining Power, University of Idaho, May 1968.

Scott, A. D., ed., *Economics of Fisheries Management: A Symposium*, Vancouver, The University of British Columbia Institute of Animal Resource Ecology, 1970, vii + 115 pp. ($5.00 paper)

Insofar as published proceedings of a symposium can conform to an orderly, integrated volume, this one is a mild success. There is no question but that significant contributions to fishery economics have been made in this book. An outstanding paper on the theoretical side is that of Quirk and Smith, which will most certainly become a standard reference on the dynamic economics of the fishery. Little can be said with respect to the volume as a whole, so each individual contribution is briefly reviewed.

"Dynamic Economic Models of Fishing" by James P. Quirk and Vernon L. Smith.

As stated by the authors, their principal objective was "to incorporate the externality and growth characteristics of a fishery into a dynamic model of general equilibrium and to compare such a competitive model with a model of optimal fishing over time." Their approach is a rather advanced mathematical one, getting into the representation of solutions of differential equations and application of the Pontryagin Maximum Principle. All of the analysis is done with rigor and imagination.

The presentation begins with a single fish stock, fixed capital endowment, and two consumption goods—fish and other. It is shown that the competitive model is inefficient as a result of the externality associated with the fish stock. The welfare maximization model is used to quantify the necessary tax required to internalize costs in the competitive model and thus overcome the externality. Next, a model with two fish species and an opportunity to change capital stocks is analyzed. After that, the general case of multiple species, capital stocks, and consumption goods is presented. The paper ends with a behavioral model of fishing-investment equilibrium, where investment is a function of the internal rate of return in the industry.

"Some Seasonal Models of the Fishing Industry" by Paul G. Bradley.

The model used by Bradley focuses on intraseasonal management in conjunction with the more commonly analyzed problem of controlling annual harvest. The crux of the problem is an additional decision variable, *viz.*, length of the fishing season, besides the usual one of annual harvest. Also, a differential equation is required to describe population dynamics within the season.

For assumed technology and prices, Bradley arrives at a model with two decision variables: (1) number of boats and (2) length of the season; since only one species is considered, there is one state variable which is population at the beginning of the season. Economic rent from the fishery is maximized with respect to the two decision variables and the equilibrium level of the state variable. A major weakness in the analysis is the tacit assumption of a zero interest rate, at least in determining the opportunity cost of fish stocks. In fact, it can be shown that under a present value criterion, the equilibrium population equation of Bradley's (15-a) will have the interest rate added to its right hand side. This result can be derived from the equilibrium equations given by Burt and Cummings [1].

"The Problem of Achieving Efficient Regulation of a Fishery" by Anthony Scott and Clive Southey.

The central concern here is an institutional arrangement to achieve economic efficiency in a fishery. Three basic organizations are analyzed:

(A) a quasi-market structure where a central agency levies taxes on, buys and sells rights to, participating 'firms';

(B) a completely decentralized multifirm fishery where allocation is entirely through the spontaneous buying and selling of transferable rights—a self-sufficient "market in rights"; and

(C) a single firm within which allocation is achieved through administrative decision or by rule.

"Economic Aspects of International Fishing Conventions" by James A. Crutchfield.

The problems associated with negotiating international controls on fisheries are discussed. A reasonable set of assumptions is specified within which negotiations must take place, and the conclusion is reached that the immediate objective should be the establishment of national quotas, even though this is quite a compromise in economic efficiency. It seems that the only alternatives are achieving minor successes or complete failure. It should also be pointed out that a quota system can be viewed as merely a transition to more favorable methods.

"Price and Allocation over Space" by George G. Judge and Takishi Takayama.

The authors present general models of spatial and temporal allocation, primarily the Takayama-Judge models familiar to most agricultural economists. Little effort is made to adapt the models to the circumstances prevalent in fisheries; and as pointed out by Quirk in his discussion of the paper, externalities are excluded by hypothesis from all industries. But externalities are a central concern in the economics of fisheries management.

"Contractual Arrangements and Resource Allocation in Marine Fisheries" by Steven N. S. Cheung.

The theme here is that contractual arrangements (in the broadest terms) are central to the economics of fisheries. The author even goes so far as to question the concept of externalities as useful and considers his contractual approach superior. There is a definite emphasis on property rights and a government-legal environment conducive to overcoming transactions costs associated with establishment of property rights. The views and arguments presented make one suspicious of the typical panacea for externalities, viz., imposition of a tax by a central agency to internalize the costs. There would seem to be strong arguments for exploring all avenues, with improved means of establishing property rights under relatively small transactions costs as a major course of action.

"Management of Marine Resources: Some Key Problems Requiring Additional Analysis" by Arnold Zellner.

This is a very able survey of some of the directions research should be taking in fishery economics. The major topics are (1) biological relationships; (2) macroeconomic aspects such as demand and supply measurement, dynamic characteristics of movements between equilibria, and stochastic attributes of the problem; (3) microeconomic analysis.

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Reference

[1] BURT, OSCAR R., AND RONALD G. CUMMINGS, "Production and Investment in Natural Resource Industries," *Am. Econ. Rev.* 60:576–590, Sept. 1970.

United Nations Economic Commission for Latin America, *Development Problems in Latin America*, Austin and London, University of Texas Press, 1970, 318 pp. ($8.50)

This is a proud book and, for economists, a cautionary one.

In 1949, while the U. S. Government was still advising—nay, lecturing—the less-developed-country governments on the efficacy of free trade and laissez-faire economics for maximizing their national incomes, Raul Prebisch and his group of economists in the ECLA secretariat began to publish a remarkable series of economic studies demonstrating just the opposite. The free-trade economics, they pointed out, suffered from a "false sense of universality." It answered to the circumstances and needs of the industrial countries (the "center") but not to those of the poor countries (the "periphery"). On the contrary, free trade even deprived the latter of some of their contribution to the increase in world product. They needed industrial development—planned—and with trade channeled so as to help.

U. S. officials and trade economists took none too kindly to this back talk. As they saw it, the ECLA case was scientifically wrong but politically powerful because of the cold-war importance of Latin America. Privately, they derided Prebisch's economics (just as they did, incidentally, the economics of agricultural income supports and intergovernmental commodity understandings).

In 20 years, however, they have learned that the U. S. position *also* derives its virtue from political power rather than scientific "objectivity." They have discovered that Prebisch's annoying insistence on a rationale accommodating both of the political elements (the center and the periphery) represents an effort to progress cooperatively toward an economically integrated world. ECLA was creating a new public conceptual environment in Latin America, much as the classical economists once did in England. Frustrating it only encouraged the advocates of autarky and authoritarianism.

This book presents the ECLA case and action proposals, as ECLA has been evolving them in those 20 years and getting some of them adopted. It consists of a concise analytical summary (38 pages), followed by 9 chapters of carefully selected and logically arranged excerpts from official expressions of "ECLA's thinking."

There is first presented a noninvidious explanation of why, over the past century, the Latin American countries have not gotten their share in the increase of world per capita production. With the application of technology in industry, the primary-product countries were supposed (in the laissez-faire theory) to get their share through the reduction of manufactured-product prices (i.e., the improvement of their terms of trade). This did not go very far. Business and labor managed to divert much of the productivity increases to raising their own incomes, which meant prices maintained above economic levels and savings for further industrial investment. A declining portion of the increased incomes was spent for Latin American primary products because of the development of substitutes, protectionism, and the natural tendency of increasing consumption to shift to manufactured products. The periphery had to import the increasing variety of manufactures. Meanwhile, technology in primary production meant unemployment and low wages. Since demand was inelastic, prices fell. Thus industrial products encountered greater demand and primary products lesser. There is built-in disequilibrium for the periphery.

The solution is "inward-directed growth"—industrial diversification of the poor-country economies. Left to the free market, such industrialization as they have is "outward-directed"—not helpful to most of the people. It produces substitutes for the imports least needed. It imposes inflation and devaluation when exports fall. Planning is required to direct industrialization toward infrastructure and the more widely used or essential products, to develop exports of such products in order to reduce

external disequilibrium, to absorb the excess manpower, and to bring along the necessary increase in food production. ECLA has been developing guiding principles for such planning.

A foreign cooperation requirement for this type of industrialization is an adequate and maintained net inflow of capital, to be tapered off as industrialization succeeds. Institutions are needed for assembling and allocating the funds and evaluating the programs. Another requirement is to encourage imports from Latin America, including manufactured products. This results in automatic reciprocity because Latin American imports are limited by their exports.

The all-Latin America requirement is to establish a common market, in spite of vested interests, so that the new industries can enjoy scale economies. Industry must be subsidized less through import restriction and more through export stimulation.

The requirements for the individual Latin American countries are to tax away the excess consumption of the 5 percent of the people who get 30 percent of the personal income and divert it, not directly to the poor, but to increased capital formation (and employment)—including the social capital of education for all and training for workers. Land tenure systems must be changed to encourage social mobility and raise rural living levels. These matters must be put clearly to the people by Latin American economists to achieve public understanding and community action.

This review does not do the argument justice. There is much detail, recognition of problems, and divergent points of view. There are weaknesses, not the least the acceptance of the free-trade economics as valid for industrial countries. But one must appreciate the effective lead given to incorporate a less-developed-country political element into international economics and hope that the intention of the latest of the proposals can be carried out. It will be difficult politically. May economists not contribute technical obstacles!

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Weintraub, D., M. Lissak, and Y. Azmon, *Moshava, Kibbutz, and Moshav: Patterns of Jewish Rural Settlement and Development in Palestine*, Ithaca, Cornell University Press, 1969, xxiii + 360 pp. ($14.50)

Klayman, Maxwell I., *The Moshav in Israel: A Case Study of Institution Building for Agricultural Development*, New York, Praeger Publishers, 1969, xvi + 371 pp. ($18.50)

The historical basis of Israel's social and economic development are the several types of agrarian settlement established in Palestine from the late 19th century. These two books deal with these settlements in very different ways. The Weintraub et al. volume is a sociological interpretation of change and development, analytical and theoretical in approach and conclusions; Klayman is a factual reportage on the economy and administration of one of the three types of settlement (the *moshav*) discussed in Weintraub and is not concerned with social analysis. Weintraub carries the story down to 1948 and the establishment of the new state; Klayman also deals with the past, but is primarily concerned with the present. Weintraub et al. are primarily concerned with an evaluation of the performance of the various types of settlement in the Palestine-Israel context; Klayman is interested in the effectiveness of the moshav as an exportable prototype for agricultural development in other countries. Both books provide information on the role of cooperative mechanisms in agrarian development. The research underlying both books enjoyed American support: Weintraub et al., a team from Hebrew University, Jerusalem, did their work with a grant from the U. S. Department of Agriculture; Klayman did part of his work (a chapter on Venezuelan adaptations of the moshav) while employed by the Inter-American Development Bank, the balance on the basis of financial support from the University of Pittsburgh.

Weintraub et al. are concerned with a sociological history of the various types of settlements of Jews in Palestine under Turkish and British rule, roughly down to the establishment of the Israeli state: the *moshava*, or colony; the *kibbutz*, or collective; and the *moshav*, or cooperative settlement. This history is presented in terms of five major themes: the nature of the original colonizing traditions that produced the three types; the social environment in which the different settlements were established; the growth potential of the different types and their actual achievements; the internal capacity of the types of settlement to develop and adapt to changing conditions; the kind of participation in the majority institutions of the developing overall Jewish settlement of Palestine. The information is presented in three blocks of chapters: the first is concerned with three case studies of the settlement types; the second with the history of development of the three types; the third with a general comparative analysis of the three in line with the five themes.

Part 1, with its case studies, was for this reviewer the most interesting, since it presents detailed analyses of how the institutions of the three settlements responded to the changing conditions of Palestine. Essentially this is a story of social adaptation; that is, change presented as the record of conscious adjustments under the constraints and flexibilities imposed by the traditions and other circumstances of the original settlement. Petach Tivka, the first successful colony, now a thriving large town near Tel Aviv, is used as the type example of the moshava. Founded by orthodox European families, determined to make an independent agricultural

settlement, the colony had its ups and downs, as various agencies controlled the waves of settlement and because of internal conflicts among the heterogeneous settlers. The original ideal stressed the transformation of the ghetto Jew into a sturdy, smallholding farmer and villager, with mutual aid mechanisms tying together the farm families, but without change in basic Jewish traditions and social organization. As the village found suitable crops (orchards, mainly), economic institutions took over and the original vague idealism was lost in a drift toward a prosperous agricultural community with internal differentiation. Outside labor was hired, and the colony solidarity disappeared. As population increased and economic success blossomed, conflicts diminished, but so did the original community; and Petach Tivka wound up as an ordinary differentiated commercial town, the center of a citrus industry.

Ein Harod is selected as the prototype of the kibbutz, and if not the very first, it was very early and experienced all the stages and phases of kibbutz development. The original collective settlements in Palestine were called *kvutza* (group) and were small communities raising single crops, living by egalitarian, communal, *gemeinschaft* principles, designed to provide a complete new Jewish social organization. Around World War I this idealistic formula had proved nonadaptive to the constraints of the natural and economic environment: the inadequate land base and agricultural specialization had led to increasing debt, and the small size of the groups contributed to severe internal tension. The solution was the emergence of the larger, more diversified and rationalized kibbutz. The authors make clear that the kibbutz form emerged mainly out of necessity, as an adaptive solution to the need for increased diversification, labor, and capital, but with considerable stimulation from Russian Jewish immigrants bearing Utopian and Marxist ideas. The kibbutz template preserved the basic ideals of the kvutza—the complete transformation of the European ghetto Jew—and accepted a dynamic, experimental format: the model of economic growth in a collective community with a growing population. What remained of consumption austerity was considered to be for practical reasons only; "voluntary asceticism" was renounced. This dynamic environment had its social costs in the form of factionalism and cleavage, the detached groups leaving to form new kibbutzim. Growing specialization led to "secondary institutionalization" to control the divisive effects of status and prestige differences and to preserve the basic forms of an egalitarian democracy, which have proved to be successful compromises. The flexibility of the kibbutz pattern is thus created by the fact that it provides for a considerable number of choices on the part of its members, even while maintaining considerable collective control over social life, the rearing of children, and decision making. Given the small size of the political entity, Palestine-Israel, and the growing integration of the entire economy, no collective settlement could hope to remain as isolated and aloof as the Hutterites in their remote and underpopulated northern Great Plains.

Nahalal, like Petach Tivka the first of its breed, is presented as the type case of the moshav, or smallholders' cooperative farm settlement. Its founders, mostly out-of-work agricultural laborers from colonies, aimed at something midway between the individualistic colony-town and the kvutza-kibbutz collective. Essentially, this meant that the distinction between the private and community spheres of autonomy and control, defined and chartered in the collectives, was left open for evolutionary emergence in the moshav. Cooperative economic institutions were built into the system to spread risks and lighten the burden of capital acquirement; but beyond this the farmer-members of the moshav were free to determine their own lives, consumption, and social participation. The moshav thus creates a "strain" in its fabric: the supraorganization of the cooperative, with its dedication to economic rationality and integration into the national economy, is a "modern" element; but the small farmer and his modest, individual life is a "peasant" element.

In any case, integration was to be assured by cooperative labor, marketing, credit, machinery, devices, and by a circular community plan, with the houses surrounding public buildings and the radial, wedge-shaped fields around the houses. Integration was confronted, however, with the same economic forces that were influencing the colony and the kibbutz: the needs for greater efficiency, diversification, and rationality, which required hired labor and threatened the egalitarian smallholder farm pattern. "Rampant development" by the ambitious was curbed by land redivision to give the second generation their own farms, a solution that created too many substandard units. Hence there has been a drift out of agriculture into urban jobs on the part of the less successful farmers and a continued tendency for the better farmers to make more money. Still, the authors say this has been kept in control and Nahalal remains a relatively conservative and egalitarian community.

In the final chapter on comparative analysis, the authors summarize the different adaptations made by the three types of settlement to the changing conditions of Palestine. With respect to economic matters, Petach Tivka, with the least specialized ideology, changed toward commercial agriculture most rapidly and extensively. The kibbutz, with the most clearly formulated utopian social charter, had to accept change formally and with conflict and doubt, not unconsciously as Petach Tivka. While the changes went in the same direction, they were more in the nature of compromises with the communal system. Nahalal stands somewhere between the other two settlements. The authors find that

while Petach Tivka has an economic secularism which promotes rapid growth, the ideologically-guided policies of the other two settlements result in more intelligent control of development. However, as between the moshav and the kibbutz, the latter has proven to be more flexible, since its communal controls avoid the contradictions of independent smallholding with rational integration. Still, the kibbutz is "socially expensive," is prone to certain economic weaknesses, and is moving toward light industry; the moshav can more easily sustain its agrarian base, conflicts notwithstanding. No clear preference can be expressed between these three groups from the standpoint of economic success, and the authors go along with the Hirschman multilinear path theory of development. However, although the authors do not mention it, one possible single standard might be ecological: the sustained-yield system of using resources. The reviewer's own observations in Israel would suggest that in this respect the kibbutz would probably come out ahead.

This is the best single work to date on the settlements of Israel, since it makes a comparative analysis of various dimensions of adaptive change. However, with some exceptions the story ends in 1948, and the reader cannot help wishing the writers had brought their study down to the present. Most of the adaptations visible in 1948 have continued, with predictable associated tensions. Perhaps a second volume is in view.

Klayman's book is really a wide-ranging treatise on certain aspects of agrarian development, using the moshav (*olim* and *ovdim* types) as a center of gravity. He provides a history of agrarian settlement in Palestine-Israel that parallels Weintraub et al., although pointed more toward economic considerations. There are chapters on the organization and planning of Israeli agriculture as a national entity; several chapters on the moshav, with special attention to economics; and several chapters on agricultural development problems and the advantages and disadvantages of the moshav form as a "package" for certain types of countries. Klayman seems to come down harder on the advantage side since he recognizes that the moshav combines a number of desirable features: it contains both the municipal and the agrarian institutions needed for the rapid development of village agriculture; it contains necessary risk-spreading cooperative mechanisms but without the commitment to a special social charter as in the case of the kibbutz; that is, it avoids extreme collectivism, which so often fails in countries with traditional kinship-dominated and particularistic social systems, since it preserves the smallholder-family production unit. It is in effect a compromise between the large commercial farm and the small family-type farm.

Klayman provides two chapters on two countries where moshav-type experiments have been instituted: Venezuela and Iran. In Venezuela the program was set up with the assistance of an Israeli team, which established a training program as well as settlement assistance. The Venezuelan land reform was the occasion for the experiment, and Klayman concludes that the moshav has been a success in providing a workable frame for new smallholder agriculture, increasing its productivity and at the same time conserving social and economic traditions. The Iran case is quite different: only one large experimental project is involved, and the peasants are manipulated from above; they are not part of an agrarian reform movement which campaigned for land reform, as in Venezuela. Klayman finds it not possible to make a conclusive evaluation and cites numerous difficulties, paramount among them being the failure of the peasants to identify with the project.

At one point in his book Klayman uses Nahalal as one "micro example" of a moshav, and the information contained in this section nicely supplements the description in Weintraub et al. In keeping with his overall emphasis, Klayman provides detailed economic data that illustrates the tendency toward differentiation in efficiency, income, and specialization among the moshav families and the tendency to acquire nonfarm employment among the less productive units. He also states that Nahalal "is not a typical moshav, as it is better than average," which might raise a question about the Weintraub et al. choice of cases. However, while Klayman is interested in economic performance, Weintraub et al. are concerned with settlement styles, and hence economic typicality is not a necessary consideration.

There is an apparent contradiction in the Klayman and Weintraub approaches in that Klayman sees the moshav as an effective institution, transferrable to other countries, while Weintraub et al. see no strong advantage for the moshav over the kibbutz and the colony. However, Klayman is dealing with transnational economic institutions and Weintraub et al. with the special environment of Israel. From these two books alone it is not possible to obtain a clear picture of the cross-cultural significance of these various Israeli types of agrarian organization.

Klayman is of course convinced of the desirability of organized cooperation in facilitating agrarian development in the emerging countries. While his approach is objective, he nevertheless does not consider alternatives to organized cooperative institutions at the production level, informal diffuse systems of exchange which might accomplish the same ends. As in Weintraub et al., there is no consideration of ecological matters; from neither book do we acquire a feeling for the relative merits of different production schemes for conservation and use of resources. Both books thus belong to the older generation of agrarian development literature, the generation which does not question development per se and does not see it in the larger context of the human use of the earth.

JOHN W. BENNETT
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Williams, Sheldon W., David A. Vose, Charles E. French, Hugh L. Cook, and Alden C. Manchester, *Organization and Competition in the Midwest Dairy Industries*, Ames, Iowa State University Press, 1970. 339 pp. ($12.50)

Regional research projects do not ordinarily contribute much to wisdom and understanding in agricultural economics, but this study of the dairy industry is a notable exception. It is the best regional research study this reviewer has ever come upon, indeed one of the best industry studies from any source.

The authors have summarized and drawn off the essence of nearly all the significant economic research done in recent years relating to the dairy industry, but they have done much more than this. They have demonstrated how to make a comprehensive, pragmatic, and perceptive analysis of a complicated industry—something one doesn't come across often in agricultural economics these days. This book should be of interest to dairy farm leaders and business men as well as agricultural economists, and it should be of special value to graduate students and young economists as an example of activist research on significant economic matters. It deserves an influence in agricultural economics far beyond the dairy industry.

Chapters 1 and 2 provide a quick summary of what has been happening in the dairy industry, and why. Topics include dairy farming, demand and consumption, industry developments (large companies, retailing, wholesaling), price and cost behavior, federal orders, price support programs, technological developments, plant operations, business organization, and numerous others. For anyone having only limited time to spend with this book, these first two chapters (pp. 3–56) and the last two (pp. 260–308) are the best to read.

Chapters 3 to 9 (pp. 57–224) provide detailed discussion and analysis of each segment of the dairy industry. Here the relevant statistics and results of other studies are brought together and supplemented with some new research and the informed opinion of the numerous contributors to the regional project itself. The analysis is in terms of market structure and its relevance for conduct and performance. This major part of the book is an excellent compendium of economic information about nearly all phases of the dairy industry and provides a good reference source.

Chapter 10 is an analysis and appraisal of industry performance in terms of such factors as technological efficiency, optimum plant and firm size, progressiveness, labor productivity, margins and profits, sales promotion costs, etc. In judging industry performance, the authors postulate "workable" rather than "perfect" competition as a socially acceptable goal; they accept not only the inevitability but also the desirability of modern industrial structure, and they understand its workings. They give the industry about average marks on performance, or maybe in some respects a little better.

One of the shortcomings of the book is its failure to provide adequate treatment of the economics of enterprise scale and its implications for ultimate market structure. There is the usual analysis showing how plant costs decline with increasing volume within the ranges of observation, and a labored effort is made to discover the minimum optimum size of dairy plants by Stigler's "survivor analysis" (based on his self-evident proposition that "the competition of different sizes of firms or plants sifts out the more efficient enterprises"). But nowhere does there seem to be recognition that as a practical matter plant size is limited mainly by the requirements of the market for its products and by transportation factors, rather than by any diseconomies of scale in the operation of the plant itself.

More serious is the failure to treat more fully the economics of scale in terms of promotion and distribution, vertical and product integration, financing, business management, etc. The authors are clearly aware of these elements as primary determinants of market structure, and they point out that the tendency to large scale is probably the dominant characteristic of the dairy industry in recent decades. But somehow they never bring themselves to a direct confrontation with the matter of enterprise scale and what to do about it, which is certainly one of the key economic issues of our time. This is the more regrettable, since some of the contributors to this study have an extraordinary degree of economic sophistication, and one wishes they had thrown caution and academic inhibitions to the winds and swung into it.

The final chapter 12 shows the authors at their best. It is what they term "a relevant compilation of ideas," and it is incisive and provocative and treats of many things and issues. It is must reading for anyone interested in any phase of the dairy industry.

One wishes that the fine team which produced this general study of the dairy industry would not now be disbanded but could take up specifically and in depth some of the important new problems confronting the industry, such as:

Will dairy farming move toward large-scale factory-type units such as those in the poultry and beef industries, or has dairying special characteristics that will prevent this?

What is the future of the demand for dairy products in view of their less favorable health image, nondairy substitutes, and changes in the eating habits of people?

What structural changes are in prospect for the dairy industry with respect to mergers, large vs. small distributors, the retail chains, the coops, and the newly-formed big producer bargaining groups? And what, if anything, should be done about them?

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Books for listing in this section should be sent to the Book Review Editor (see inside front cover for address).

Books Received

Badger, Daniel D., ed., *Attaining Economic Development—How the Great Plains Can Contribute to the U. S. Economy,* Proceedings of Seminar, Great Plains Agricultural Council Publications No. 49, Stillwater, Oklahoma State University, 1970, vi + 234 pp. $3.00 paper.

Bakken, Henry H., ed., *Futures Trading in Livestock; Origins and Concepts,* Chicago Mercantile Exchange, Madison, Mimir Publishers Inc., 1970, ix + 248 pp. Price unknown.

Bartel, Irene Brown, *No Drums or Thunder,* San Antonio, The Naylor Company, 1970, ix + 83 pp. $3.95.

Chao, Kang, *Agricultural Production in Communist China, 1949–1965,* Madison, The University of Wisconsin Press, 1970, xv + 357 pp. $15.00.

Clark, Colin, and Margaret Haswell, *The Economics of Subsistence Agriculture,* 4th ed., New York, St. Martin's Press, 1970, xiii + 267 pp. $11.00.

Cline, William R., *Economic Consequences of a Land Reform in Brazil,* Amsterdam, North-Holland Publishing Company, 1970, xv + 213 pp. $14.00.

Crosson, Pierre R., *Agricultural Development and Productivity; Lessons from the Chilean Experience,* Baltimore, The Johns Hopkins Press for Resources for the Future, 1970, xvi + 198 pp. $7.00.

Desai, D. K., and S. B. Tambad, *Farm Finance by a Commercial Bank; A Case Study of the Syndicate Bank,* Ahmedabad, Indian Institute of Management, 1970, ii + 84 pp. Rs. 7 paper.

Donaldson, G. F., *Optimum Harvesting Systems for Cereals; An Assessment for South-East England, England,* Wye College (Univ. of London), 1970, vi + 92 pp. £ 1 paper.

Dunn, J. D., and Frank M. Rachel, *Wage and Salary Administration: Total Compensation Systems,* New York McGraw-Hill Book Company, 1971, xii + 468 pp. $12.50.

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Filangieri, Angerio, and Giuseppe Metto, *L'analisi Beneficio-Costo Nella Valutazione Della Convenienze di Uno Schema Irriguo,* Portici, University of Naples, 1970, 147 pp. Price unknown. Paper.

Fletcher, Lehman B., Eric Graber, William C. Merrill, and Erik Thorbecke, *Guatemala's Economic Development; The Role of Agriculture,* Ames, The Iowa State University Press, 1970, ix + 212 pp. $4.95.

Food and Agriculture Organization of the United Nations, *Fertilizers; An Annual Review of World Production, Consumption, Trade and Prices, 1969,* Rome, 1970, x + 185 pp. $4.50 or 36s paper.

Food and Agriculture Organization of the United Nations, *Processed Fruit and Vegetables; Trends in World Production and Trade of Citrus Products, Canned Peaches and Apricots, and Tomato Products,* Commodity Bulletin Series 47, Rome, 1970, vi + 76 pp. $2.00 or 16s paper.

Food and Agriculture Organization of the United Nations, *Production Yearbook, 1969, Vol. 23,* Rome, 1970, xvi + 825 pp. $10.00-80s-FF 50.

Gilpin, Alan, *Dictionary of Economic Terms,* 2nd

ed., New York, Philosophical Library Inc., 1970, 276 pp. $12.50.

Griggs, John E., *Evaluating Marketing Change; An Application of Systems Theory,* East Lansing, Michigan State University, 1970, xiv + 136 pp. $8.00.

Gupta, V. K., T. P. Gopalaswamy and D. P. Mathur, *Under Utilization in Sheller Rice Mills; A Study in Selected Districts of Andhra Pradesh,* Ahmedabad, Indian Institute of Management, 1970, ii + 112 pp. Rs. 8 paper.

Hatcher, John, *Rural Economy and Society in The Duchy of Cornwall 1300–1500,* New York, Cambridge University Press, 1970, xiv + 322 pp. $16.00.

Hilton, George W., *The Transportation Act of 1958, A Decade of Experience,* Bloomington, Indiana University Press, 1969, x + 262 pp. $7.95.

Hirsch, Eva, *Poverty and Plenty on the Turkish Farm; A Study of Income Distribution in Turkish Agriculture,* New York, Columbia University Press, 1970, xv + 313 pp. $6.00 paper.

Inglett, G. E., ed., *Corn: Culture, Processing, Products,* Westport, The AVI Publishing Company, Inc., 1970, ix + 369 pp. Price unknown.

Joravsky, David, *The Lysenko Affair,* Russian Research Center Studies, 61, Cambridge, Harvard University Press, 1970, xiii + 460 pp. $13.95.

Kneese, Allen V., Robert U. Ayres, and Ralph C. D'Arge, *Economics and the Environment; A Materials Balance Approach,* Baltimore, The Johns Hopkins Press for Resources for the Future, 1971, x + 120 pp. $2.50 paper.

Lazarides, M., *The Grasses of Central Australia,* Canberra, Australian National University Press, 1970, xi + 282 pp. $10.00.

Meadows, Dennis L., *Dynamics of Commodity Production Cycles,* Cambridge, Wright-Allen Press, Inc., 1970, xi + 104 pp. $14.75.

Miller, C. W., *Today,* San Antonio, The Naylor Company, 1970, xi + 126 pp. $4.95.

Nelkin, Dorothy, *On the Season: Aspects of the Migrant Labor System,* New York State School of Industrial and Labor Relations, Ithaca, Cornell University, 1970, xi + 85 pp. $2.25 paper.

Nickson, Jack W. Jr., *Economics and Social Choice,* New York, McGraw-Hill Book Company, 1971, x + 278 pp. $5.95 paper.

Parthasarathy, G., and B. Prasada Rao, *Implementation of Land Reforms in Andhra Pradesh,* Calcutta, Scientific Book Agency, 1969, xii + 392 pp. Rs. 20.

Patel, D. A., and D. K. Desai, *Management in the Seed Industry; A Study on Hybrid Maize and Jowar Seeds in Mysore State,* Ahmedabad, Indian Institute of Management, 1970, ii + 124 pp. Rs. 7 paper.

Pearson, Scott R., *Petroleum and the Nigerian Economy,* Stanford, Stanford Press, 1970, xiv + 235 pp. $8.75.

Reserve Bank of India, *Studies in Agricultural Credit,* Bombay, 1970, 209 pp. Rs. 14 paper.

Reynolds, Clark W., *The Mexican Economy; Twentieth-Century Structure and Growth,* New Haven, Yale University Press, 1970, xxiv + 468 pp. $13.50.

Russell, Clifford S., David G. Arey and Robert W. Kates, *Drought and Water Supply; Implications of the Massachusetts Experience for Municipal Planning,* Baltimore, The Johns Hopkins Press for Resources for the Future, 1970, xiv + 232 pp. $8.00.

Schapsmeier, Edward L. and Frederick H., *Prophet in Politics: Henry A. Wallace and the War Years, 1940–1965,* Ames, The Iowa State University Press, 1970, xv + 268 pp. Price unknown.

Scott, Roy V., *The Reluctant Farmer; The Rise of Agricultural Extension to 1914,* Urbana, University of Illinois Press, xi + 362 pp. $8.95.

Singh, Tarlok, *Towards an Integrated Society; Reflections on Planning, Social Policy and Rural Institutions,* Westport, Conn., Greenwood Publishing Corp., 1969, xii + 554 pp. Price unknown.

Tregear, T. R., *An Economic Geography of China,* New York, American Elsevier Publishing Co., Inc., 1970, xii + 276 pp. $12.75.

Webster, John, *Introduction to Fungi,* Cambridge, Cambridge University Press, 1970, viii + 424 pp. $10.50.

Announcements

ANNUAL MEETING
AMERICAN AGRICULTURAL ECONOMICS ASSOCIATION
Southern Illinois University
Carbondale, Illinois
August 15-18, 1971

Format of the 1971 Annual Program

Some variations in programming were tried by Dale Hathaway last year, and I shall follow essentially the same format. The self-initiated scholarship that regularly is submitted to *AJAE* will form the bases for discussions at the Annual Meeting. The Editor has kept me informed of the flow of manuscripts that have been reviewed and accepted for publication in the Journal. Insofar as these papers have offered subject matter that can be integrated into general topics chosen for the Annual Meeting program, I have invited the authors to summarize and discuss the results of their research. This applies to papers that have already been published in issues of the Journal preceding the Annual Meeting and to those accepted for publication in later issues. Above all, I take the position that the program should be for those who attend.

There is no thematic design for the annual meeting; hence I shall expect to invite a heterogeneous variety of papers. However, these papers will not be automatically published as in the past. Authors of papers may, at their option, present manuscripts based on their papers for review and possible publication in the Journal in the same manner as others seeking publication in the February, May, August, and November issues.

The Proceedings issue (December) will contain abstracts of all papers presented and discussed at the Annual Meeting, regardless of whether an article has already been published or accepted for publication. As heretofore, the December issue will also contain the Presidential Address, the invited general seminar papers, committee reports, and Association business.

For the Proceedings issue, abstracts can be longer (maximum 250 words) than for regular articles (these are having to be restricted to 100 words to qualify for the *Journal of Economic Literature*). Additionally, if a practical method can be devised, the Proceedings issue will carry summaries of the remarks by those participating in the discussions. We are still experimenting with this method.

The major deviation from last year's format relates to contributed papers. In the general seminar subject matter areas, contributed papers will be accepted. C. E. French, Purdue University, assisted by the program organizers for the general seminar sessions, will decide on contributed papers policy. Topical areas for the seminars follow.

General Topical Areas for Seminars at Annual Meeting

1. International Agricultural Adjustment
   Program Organizer: Lyle P. Schertz
   Deputy Administrator
   Foreign Economic Development Service
   U. S. Department of Agriculture
   Washington, D.C. 20250

2. Rural Development, Community Development, and Human Resources
   Program Organizer: Henry J. Meenan, Head
   Department of Agricultural Economics
   University of Arkansas
   Fayetteville, Arkansas 72701

3. Organizing and Financing Agricultural Production in the 70's (Macro Problems)
   Program Organizer: Eric Thor, Administrator
   Farmer Cooperative Service
   U. S. Department of Agriculture
   Washington, D.C. 20250
4. The Role of Forestry and Natural Resources in Economic Development
   Program Organizer: Hans M. Gregersen
   School of Forestry
   110 Green Hall
   University of Minnesota
   St. Paul, Minnesota 55101
5. The Impacts of Changing Technology and Institutional Forces on the Management of Agricultural Firms (Micro Problems)
   Program Organizer: W. Neill Schaller
   Associate Director
   Farm Foundation
   600 S. Michigan Avenue
   Chicago, Illinois 60605
6. Environmental Quality Problems; Nature, Causes, and Approaches to Solutions: Implications for Agricultural Economists.
   Program Organizer: Kenneth R. Tefertiller, Head
   Department of Agricultural Economics
   University of Florida
   Gainesville, Florida 32601

In addition to these major seminar areas, of course, there will be the principal addresses of the morning sessions; the sectional papers on specific topics, selected from suggestions of the membership; the other parts of the program, such as the Fellows Address, Awards, etc.

JIMMYE S. HILLMAN, *President*

AAEA COMMITTEE STRUCTURE, 1970-1971

Awards Committee

Chester Baker, Chairman, Illinois, 1967

Distinguished Undergraduate Teacher Award

John Malone, Jr., Chairman, Nevada, 1968
John Timmons, Iowa State, 1968
Milton Snodgrass, California Polytechnic, 1969
Jack Thompson, Georgia, 1970
David K. Armstrong, Michigan State, 1970
Bob Christensen, Massachusetts, 1970
John Neal, Texas A&M (student)

Extension Award

Gene McMurtry, Chairman, Virginia Polytechnic, 1969
Charles Beer, FES, USDA, 1969
John Bottum, FES, USDA, 1970
Clarence Klinger, Missouri 1968
Henry Meenan, Arkansas, 1970
Ray Penn, Wisconsin, 1969
Luther T. Wallace, California, Berkeley, 1970
Jean Wyckoff, Massachusetts, 1970

Published Research Award

J. O. Gerald, Chairman, ERS, USDA, 1969
Dale Knight, Kansas State, 1969
Bud Stanton, Cornell, 1969
Howard Williams, Ohio State, 1969
M. L. Lerohl, Ottawa, Ontario, 1969
Joseph Havlicek, Jr., Purdue, 1969
Bill Martin, Arizona, 1970
William Motes, EDD, ERS, USDA, 1970
Billy Lessley, Maryland, 1970
Walter Butcher, Washington State, 1970
Carlton Dennis, Agway Corporation, 1970
J. A. Seagraves, North Carolina State, 1970
Lee Bawden, Wisconsin, 1970

Master's Thesis Award

Eldon Weeks, Chairman, Washington State, 1967
Dale Anderson, North Dakota State, 1969
Wallace Rehberg, Washington State, 1970
Tom Hady, ERS, USDA, 1969
Leroy Quance, Oklahoma State, 1969
Jim Kendrich, Nebraska, 1969
Robert Rizek, ERS, USDA, 1969
David Allee, Cornell, 1970
Bob Herdt, Illinois, 1970
Tom Williams, Southern U., Louisiana, 1970
Jim Youde, Oregon State, 1970
Eric Oesterle, Purdue, 1970
Steven Lytle, Clemson, 1970

Ph.D. Dissertation Award

Willard Williams, Chairman, Texas Tech., 1967
Burl Back, USDA, 1969
Gail L. Cramer, Montana State, 1969
Joe Purcell, Georgia, 1969
Wayne Purcell, Oklahoma, 1969
Walt Miller, ERS, USDA, 1970
Fred Tyner, Florida, 1970
Verner G. Hurt, Mississippi State, 1970
Frank Orazem, Kansas State, 1970
Don Farris, Texas A&M, 1970
Frank Smith, Minnesota, 1970
Hugh Cook, Wisconsin, 1970
Dan Bromley, Wisconsin, 1970
Royce Hinton, Illinois, 1970

Audit Committee

Fred E. Justus, Kentucky, 1970
Jim Criswell, Kentucky, 1970

Bibliographical Committee

Lee Day, Chairman, Pennsylvania State, 1969
Fred Abel, USDA, 1969
Ivan Schmedemann, Texas A&M, 1970
Edwin Farris, Virginia Polytechnic, 1970
W. Darčovich, Canada Dept. of Agriculture, 1970

Brochure Committee

Ralph J. Mutti, Chairman, Illinois, 1969
Sydney James, Iowa State, 1969
Dave Downey, Purdue, 1969

Directory Committee

Bob Rudd, Chairman, Kentucky, 1969
John Redman, Kentucky, 1969
Clifton Cox, Armour, Chicago, 1969
Burt Sundquist, USDA, 1969

Educational Committee

James Nielson, Chairman, Washington State, 1969
Lester Manderscheid, Michigan State, 1969
Linley Juers, ERS, USDA, 1969
Fred Mangum, North Carolina State, 1969
Oscar Hoffman, Northbrook, Illinois, 1969
John Helmberger, Minnesota, 1969
John Wildermuth, Arizona, 1970
Lee Kolmer, Iowa State, 1970
John McNeely, Texas A&M, 1970

Economic Statistics Commiteee

James Bonnen, Chairman, Michigan State, 1969
John Schnittker, Kansas State, 1969
George Tolley, Chicago, 1969
James Hildreth, Farm Foundation, 1969
George Judge, Illinois, 1969
Harry Trelogan, USDA, 1970

Employment Services Committee

Loys Mather, Chairman, Kentucky, 1968
David H. Boyne, Ohio State, 1969
Almon T. Mace, Madison College, 1969
Melvin Janssen, ERS, USDA, 1969

Extension Affairs Committee

Eber Eldridge, Chairman, Iowa State, 1968
Wallace Barr, Ohio State, 1969
John S. Bottum, ERS, USDA, 1970
Neill Schaller, Farm Foundation, 1970
Henry Wadsworth, Purdue, 1970
Clay Moore, Texas A&M, 1970

Fellows Election Committee

George Brandow, Chairman, Pennsylvania State, 1966
Harry Trelogan, USDA, 1967
Maurice Kelso, Arizona, 1968
Nathan Koffsky, Washington, D.C., 1969
Glenn Johnson, Michigan State, 1970

Industry Committee

Charles Erickson, Chairman, Cargill & Co., 1968
William Bunkers, Anheuser-Busch, 1968
George Allen, W. R. Grace & Co., 1969
Vern Schneider, Am. Inst. of Cooperation, 1970
Dick Goodman, Cook & Co., 1970
Claude Scroggs, Southern States Coop., 1970
Paul Baumgart, Safeway Stores, 1970
Jerry Quackenbush, ADA, 1970
Glenn Heitz, Federal Land Bank, 1970
Ray Seltzer, Dunlap & Associates, 1970
Shelby Robert, Pet, Inc., 1970

International Committee

Erik Thorbecke, Chairman, Iowa State, 1969
Walter Falcon, Harvard, 1966
Wyn Owen, Colorado, 1968
Eldon Smith, Kentucky, 1969
Nicolaas Luykx, East-West Food Institute, 1970
Earl Heady, Iowa State, 1970
Tony Tang, Vanderbilt, 1970
Max Myers, South Dakota State, 1970
Lyle Schertz, FES, USDA, 1970

Investment Committee

John Redman, Kentucky, 1969
Del Kearl, Cornell, 1958
Dale Butz, Illinois Agricultural Assn., Bloomington, 1970

Membership Committee

Quentin West, Chairman, 1965
E. E. Broadbent, 1969
LaVon S. Fife, 1968
Del Kearl, 1958
N. Keith Roberts, 1968
Fred H. Wiegmann, 1968
T. T. Williams, 1968

Sustaining Membership Subcommittee

Del Kearl, Chairman, Cornell, 1964
S. Kent Christensen, National Assn. of Food Chains, 1965
Charles Sayre, Staple Cotton Coop. Assn., 1965
Lauren Soth, Des Moines Register and Tribune, 1965
Roy Stout, Coca Cola, Atlanta, 1970
Joe Marshall, Cotton Producers Assn., 1970
Ray Seltzer, Dunlap and Associates, 1970

Nominating Committee

Dale Hathaway, Chairman, Michigan State, 1970
Chester Baker, Illinois, 1970
John Bottum, ERS, USDA, 1970
William Folz, Idaho, 1970
Marshall Godwin, Texas A&M, 1970
Richard Goodman, Cook Industries, Inc., 1970
Linley Juers, ERS, USDA, 1970
John Redman (ex-officio), Kentucky, 1970

Postwar Literature Review Committee

Lee Martin, Chairman, Minnesota, 1967
Glenn Johnson, Michigan State, 1967
Maurice Kelso, Arizona, 1967
John Doll, Missouri, 1968
Louis Upchurch, USDA, 1967
Pat Madden, Pennsylvania State, 1969
Peter Helmberger, Wisconsin, 1969
Ed Tyrchniewicz, Manitoba, Winnipeg, 1969

Professional Activities Committee

James Hildreth, Chairman, Farm Foundation, 1968
Eber Eldridge, Iowa State, 1969
Kenneth Tefertiller, Florida, 1968
Louis Upchurch, USDA, 1968
Jim Nielson, Washington State, 1970
Erik Thorbecke, Iowa State, 1970
Charles Erickson, Cargill & Company, 1970
Ray Farrish, Connecticut, 1970
James Plaxico, Oklahoma State, 1970

Student Affairs Committee

John Sjo, Chairman, Kansas State, 1969
Robert Beck, Kentucky, 1968
Donald G. Smith, Illinois, 1968
Lowell Wilson, Auburn, 1968
Bob Koch, Rutgers, 1969
Leo V. Mayer, Iowa State, 1970
Don J. Epp, Pennsylvania State, 1970
Dan Badger, Oklahoma State, 1970

Tellers Committee

Frank Bordeaux, Jr., Kentucky, 1970
Bruce Beattie, Kentucky, 1970

Visiting Professor Committee

James Hildreth, Chairman, Farm Foundation, 1969
Emiel Owens, Minnesota, 1969
John Thompson, South Dakota State, 1969
Andrew Vanvig, Wyoming, 1969

AAEA Representative to National Research Council

George Brandow, Pennsylvania State, 1970

AAEA Representative to National Bureau of Economic Research

Harold Halcrow, Illinois, 1970

AAEA Liaison to American Society of Agronomy

C. R. Hoglund, Michigan State, 1970

Local Arrangements, Winter, 1970

Ed Jones, The Michigan Bank, Detroit

Local Arrangements, Summer, 1971

Walter J. Wills, Southern Illinois University

WESTERN AGRICULTURAL ECONOMICS ASSOCIATION

The 1971 Annual Meeting of the Western Agricultural Economics Association will be held at Squaw Valley, California, July 25–27.

News Notes

CORNELL UNIVERSITY

APPOINTMENTS: **Richard Boisvert,** formerly of the University of Minnesota, and **L. Duane Chapman,** formerly of the University of Tennessee, assistant professors.

ECONOMIC RESEARCH SERVICE, USDA

(EDD is Economic Development Division; ESAD is Economic and Statistical Analysis Division; FDTD is Foreign Development and Trade Division; FPED is Farm Production and Economics Division; FRAD is Foreign Regional Analysis Division; MED is Marketing Economics Division; NRED is Natural Resource Economics Division.)

APPOINTMENTS: **Warren R. Bailey,** formerly deputy director, FPED, acting director; **Everet Wayne Denny,** FRAD; **Samuel L. Donald,** USDA liaison officer, Alcorn A&M College, Lorman, Mississippi; **Gerald Feaster,** MED: **Ralph G. Forsht,** NRED, University Park, Pennsylvania; **Richard L. Harwell,** FPED, Stillwater, Oklahoma; **Richard M. Kennedy,** USDA liaison officer at Virginia State College, Petersburg, Virginia; **Charles A. O'Dell,** USDA liaison officer at Prairie View A&M College, Prairie View, Texas; **William H. Pietsch,** NRED, Pullman, Washington; **Bobby Robinson,** FPED; **Herbert W. Steiner,** FRAD; **W. B. Sundquist,** formerly director, FPED, acting deputy administrator, ERS.

LEAVE: **Alan R. Bird,** EDD, to the National Area Development Institute.

TRANSFERS AND REASSIGNMENTS: **Sanford Belden,** MED, from Lafayette, Indiana, to Cornell University; **Max Bowser,** MED, from University Park, Pennsylvania, to the Agricultural Stabilization and Conservation Service, Washington, D.C.; **Cleveland Eley,** from Office of Administrator to MED; **William P. Huth,** from FDTD to Foreign Agricultural Service; **Joe Imel,** MED, from Madison, Wisconsin, to Washington, D.C.; **John Lawler,** from MED to ESAD, Washington, D.C.; **Theodore Moriak,** MED, from Albany, California, to Washington, D.C.; **Richard C. McArdle,** from NRED to FRAD; **C. Kyle Randall,** from Office of the Secretary to outlook and situation officer, Office of Administrator; **Gary Taylor,** from NRED to National Water Commission, Washington, D.C.; **Glenn R. Samson,** from FRAD to PASA assignment in Lesotho and Swaziland; **Duane Smith,** MED, from University of New Hampshire to University of Maine.

FOOD RESEARCH INSTITUTE, STANFORD UNIVERSITY

APPOINTMENTS: **Arjun Adlakha,** Ph.D. Michigan, research demographer; **Sven W. Arndt,** California at Santa Cruz, visiting professor, Spring Quarter 1971; **Tetteh A. Kofi,** Ph.D. California, acting assistant professor, 1970–1971; **Kenneth A. Leslie,** University of the West Indies, Kingston, Jamaica, visiting scholar, 1970–1971.

LEAVES: **Scott R. Pearson,** assistant professor, economist, Presidential Commission on International Trade and Investment Policy, 1970–1971; **Peter Timmer,** assistant professor, associate advisor to the Indonesian Government with the Development Advisory Service of Harvard University, 1970–1971.

UNIVERSITY OF ILLINOIS

APPOINTMENTS: **H. J. Schweitzer,** formerly associate professor, assistant director of Cooperative Extension Service and assistant director of the Experiment Station.

LEAVES: **Harold G. Halcrow,** sabbatical, six months, Stanford Food Research Institute and University of California, Berkeley; **J. C. van Es,** visiting assistant professor Department of Rural Sociology, University of Wisconsin, seven months ending August 31, 1971.

ARTHUR D. LITTLE, INC.

APPOINTMENTS: **Richard J. Lacroix,** University of Campinas, Brazil, special consultant in agribusiness; **John M. Lovorn,** FHA, USDA, staff consultant in agribusiness; **Dennis H. Wood,** J. D. Harvard, staff consultant in agribusiness.

TRANSFERS: **Robert E. Lee,** from Arthur D. Little, Inc., Cambridge, to Arthur D. Little, Ltda., Belo Horizonte, Brazil; **Harry Trask,** from Fertilizer and Chemical Group to Agribusiness Group.

UNIVERSITY OF MISSOURI

APPOINTMENTS: **Francis P. McCamley,** formerly of Oklahoma State University, assistant professor; **Johannes deGraaf,** M.S. Massachusetts, instructor.

AWARDS: **Randall E. Torgerson,** Curators Publication Award for 1970, for *Producer Power at the Bargaining Table* (University of Missouri Press)—first recipient of this award for best book published by an assistant professor; **Donald R. Levi,** Gamma Sigma Delta Junior Faculty Award of Merit.

MONTANA STATE UNIVERSITY

APPOINTMENTS: **Donald K. Rose,** Ph.D. Colorado, and **Gilbert G. Biebink,** J.D. Minnesota, staff.

OHIO STATE UNIVERSITY

APPOINTMENTS: **Reed Taylor,** formerly with Monsanto, associate professor; **David Francis,** Ph.D. Cornell, assistant professor.

LEAVES: **Howard Steele,** sabbatical, Foreign Economic Development Service, Washington, D.C., until January 1972; **Howard Williams,** sabbatical, American Stabilization and Conservation Service, Washington, D.C., until February 1972.

UNIVERSITY OF WISCONSIN

APPOINTMENT: **Gayle S. Willett,** Ph.D. Wisconsin, assistant professor.

LEAVE: **William E. Saupe,** to participate in University of Wisconsin-AID program for agricultural development at Federal University of Rio Grande do Sul, Brazil, two years.

OTHER APPOINTMENTS

Peter J. Barry, formerly of the University of Guelph, assistant professor, Texas A&M University.

Meir Chayat, Ph.D. Cornell, Planning and Development Center, Ministry of Agriculture, Tel Aviv, Israel.

James M. Conrad, Ph.D. Kentucky, head of Department of Business Administration, Northwood College, West Baden, Indiana.

Harold Cosper, Ph.D. Nebraska, Natural Resource Economics Division, ERS, USDA, stationed at Oxford, Mississippi.

Robert D. Dahle, extension associate professor of economics, North Carolina State University.

Gerald Feaster, Ph.D. Kentucky, Market Development and Performance Branch, MED, ERS, USDA.

Carroll Garner, M.S. Arkansas, instructor, University of Arkansas.

Brook A. Greene, Ph.D. Cornell, assistant professor, American University, Beirut.

Thomas I. Gunn, chairman of newly established Department of Agricultural Economics, Fresno State College, Fresno, California.

Bernard Hoffnar, formerly with ERS, USDA, consultant to Office of Planning, Research, and Evaluation, Office of Economic Opportunity, Washington, D.C.

John D. Hyslop, Ph.D. Minnesota, agricultural economist, Foreign Economic Development Service, USDA.

Larry C. Jenkins, Ph.D. Kentucky, University of Missouri-Rolla.

Gary Keathley, formerly of the University of Arkansas, assistant director of commodity department of Arkansas Farm Bureau Federation.

Eugene Anderson Laurent, Ph.D. Clemson, assistant professor, Environmental Resources Center, Georgia Institute of Technology.

Barry R. Lawson, graduate student Cornell, assistant professor, Wayne State University.

Larry Seistritz, Ph.D. Nebraska, agricultural economics staff, North Dakota State University.

Jack N. Lewis, formerly of the University of New England, Australia, director of corporate planning for the international Wool Secretariat, succeeding **E. G. Carter** on his retirement in July.

Chuan Chian Lim, Ph.D. Missouri, University of Missouri Extension Division.

Gaines Howard Liner, Ph.D. candidate, Clemson, assistant professor of economics, University of North Carolina.

Ronald G. Lorentson, Ph.D. candidate, Washington, acting assistant professor, University of California, Berkeley.

Ralph Gene Martin, formerly of the University of Arkansas, director of soybean division of Arkansas Farm Bureau Federation.

Wayne Pfeiffer, Ph.D. Nebraska, Provincial Department of Food and Agriculture, Toronto, Canada.

Charles Robertson, Ph.D. Cornell, Overseas Development Administration, London.

Wayne A. Schutjer, Pennsylvania State University, director of the Research and Training Network of the Agricultural Development Council, New York.

Geoffrey Shepherd, ret. Iowa State University, chief economist of Indonesia Rice Marketing Team, Djakarta, for Weitz-Hettelsater Engineers under contract to USAID, six months.

Arlen Skarr, Ph.D. Nebraska, economics staff, Mankato State College, Mankato, Minnesota.

Martin Lonnie Spurgeon, Ph.D. Missouri, Mid-America Dairyman, Springfield, Missouri.

Arthur I. Strong, III, Ph.D. Wisconsin, program planner with Bureau of Budget, City of New York.

Eric Tollens, Michigan State, faculty of University of Louvain, to be stationed at Kinshasa, Congo, Africa.

Joseph S. Weiss, Ph.D. Cornell, Louis Berger, Inc., Consultants, Tehran, Iran.

OTHER LEAVES

Garland Wood, Michigan State University, returned from Balcarce, Argentina, where he was chief of party, MSU/AID.

OBITUARIES

Elwyn Loomis Cady, Sr., 72, agricultural economist and lawyer, died in December 1970 at Independence, Missouri. Born in Meadville, Missouri, he received his bachelor's degree at the University of Missouri, master's and doctorate degrees at Iowa State University, and a doctor of laws degree at the University of Missouri-Kansas City.

Cady served as an agricultural extension marketing specialist at Iowa State University from 1921 to 1938. During that time he also spent three summers with the U. S. Department of Agriculture where he aided in drafting the federal crop insurance act. After periods of service with the Office of Price Administration in World War II, he held several positions in private industry in Turkey and Newfoundland and in Kansas City.

In the past ten years Dr. Cady had practiced law with his son, Elwyn L. Cady, Jr., in Kansas City, Missouri.

Harrison M. Dixon, 82, whose career as an agricultural economist with the U. S. Department of Agriculture spanned the years 1911 to 1956, died in December 1970. He was director of agricultural economics programs for the Federal Extension Service when he retired in 1956. He joined the Extension Service in 1922 and was instrumental in initiating agricultural outlook extension work in 1924. During World War II he had a major role in conducting the USDA emergency farm labor program.

Mr. Dixon was vice-president of the American Farm Economic Association in 1936. From 1939 to 1941 he was chairman of a committee appointed by AFEA on farm management terminology.

A son, Richard, of New Orleans, and a daughter, Mrs. Robert Goelz of Orinda, California, survive.

Garret L. Jordan, professor emeritus of the University of Illinois, died in November 1969 at age 73. Dr. Jordan had served the University from 1927 until his retirement in 1960. During this period he served as assistant to the Dean of the College of Agriculture from 1929 to 1938 and twice served as acting head of the Department of Agricultural Economics. Born in Whitley County, Indiana, he received his B.S. degree from Purdue University and M.A. and Ph.D. degrees from the University of Illinois. Prior to joining the staff at Illinois, he did banking and farm credit work in Indiana and Florida.

Dr. Jordan was active in research and teaching in price forecasting and marketing. During his long service on the Illinois faculty, he taught hundreds of students in his classes on agricultural finance, prices, statistics, and marketing. He specialized in commodity futures; he published widely in the field and served as a private consultant after his retirement.

Jim F. Tomlinson, assistant professor in the Department of Agricultural Economics at Oklahoma State University, died in November 1970. Born in Elk City, Oklahoma, in 1905, he received the B.S. and M.S. degrees from Oklahoma State University. His widow and four sons survive.

Prior to joining the faculty in agricultural economics at Oklahoma State in 1956, Professor Tomlinson taught vocational agriculture in Oklahoma, was head of the agricultural department at Cameron College, and was farm coordinator for the Oklahoma Agricultural Experiment Station. His contributions to agriculture were many and varied. Perhaps his outstanding contribution was the development of agricultural production packages involving new research results. This work greatly expedited and accelerated introduction of new technology into farming systems.

DOCTORAL DEGREES CONFERRED IN AGRICULTURAL ECONOMICS, 1970

UNIVERSITY OF CALIFORNIA, BERKELEY

Giorgio Cingolani, Graduate, Catholic University of the Sacred Heart, Milan, Italy, 1959; M.S. University of California, 1964; Ph.D. *Analysis of the Dynamics of Treefruit Acreage in California's Central Valley.*

Richard S. Johnston, A.B. Washington State University, 1960; Ph.D. *The Growth of Firms in Some Food Marketing and Processing Industries.*

Tatsuo Kobayashi, B. A. Beloit College, 1957; M.S. University of Missouri, 1959; Ph.D. *The Land Reform in Japan.*

Richard J. Marasco, B.S. Utah State University, 1965; M.S. Utah State University, 1966; Ph.D. *The Organization of the California Tuna Industry: An Economic Analysis of the Relations Between Market Performance and Conservation in the Fisheries.*

Timothy Mount, B.Sc. University of London, 1963; M.S. Oregon State University, 1964; M.A. University of California, 1967; Ph.D. *An Analysis of Production Behavior Incorporating Technical Change.*

Rodrigo Mujica, Graduate, Catholic University of Chile, 1965; M.S. University of California, 1966; M.A. University of California, 1967; Ph.D. *Satiation Levels and Consumer Demand: Analysis of a Chilean Family Expenditures Survey.*

Gholamreza Soltani-Mohammadi, Graduate, University of Tehran, 1964; M.S. University of California, 1967; Ph.D. *Efficient Development of*

Irrigated Agriculture in Iran: The Problem of Choice Between Irrigation Techniques.

Gail Eric Updegraff, B.S. Ohio State University, 1965; M.S. Iowa State, 1967; Ph.D. *The Economics of Sewage Disposal in A Coastal Urban Area: A Case Study of the Monterey Peninsula, California.*

UNIVERSITY OF CALIFORNIA, DAVIS

Nazmi Demir, Graduate, University of Ankara, 1962; M.S. University of California, 1967; Ph.D. *Input-Output Projections (1975, 1980, 1985) of California Resource Requirements with Emphasis on Technological Change.*

Russell Lynn Gum, M.S. University of California, 1964; Ph.D. *Analysis of Factors Influencing the Use of State and Federal Outdoor Recreation Sites in the West.*

Andrew Desmond O'Rourke, A.B. Queens University, Belfast, 1960; B. Comm. National University of Ireland, 1963; M.S. University of California, 1968; Ph.D. *California Fresh and Frozen Fish Trade.*

CLEMSON UNIVERSITY

Eugene Anderson Laurent, B.S. University of Georgia, 1965; M.S. University of Nebraska, 1967; Ph.D. *Economic-Ecologic Analysis in the Charleston Metropolitan Region: An Input-Output Study.*

UNIVERSITY OF CONNECTICUT

Shirley Collins Browning, B.S. University of Kentucky, 1964; M.S. University of Kentucky, 1967; Ph.D. *Analysis of the Optimum Carryover Level for Grains in Relation to Foreign Aid Requirements.*

Harold Garth Coffin, B.Sc. McGill University, 1962; M.S. University of Connecticut, 1967; Ph.D. *An Economic Analysis of Import Demand for Wheat and Flour in World Markets.*

Andrew Anton Duymovic, B.S. Cornell University, 1962; M.S. University of Connecticut, 1967; Ph.D. *The Effect of Income Transfers on the Distribution of Income in the United States.*

CORNELL UNIVERSITY

Allen Clifford Bjergo, B.S. North Dakota State University, 1962; M.A. New Mexico State University, 1964; Ph.D. *A Study of Decision-Making in Twenty-One New York Farm Families.*

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Richard Lee Meyer, B.S. University of Minnesota, 1959; M.S. Cornell University, 1967; Ph.D. *Debt Repayment Capacity of the Chilean Agrarian Reform Beneficiaries.*

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UNIVERSITY OF HAWAII

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A Spatial Equilibrium Model of the Beef Industry in the United States.

UNIVERSITY OF ILLINOIS

Eldon Dean Baldwin, B.S. Ohio State University, 1963; M.S. University of Illinois, 1967; Ph.D. *Optimal Market Structure Adjustments to Field Shelling of Corn.*

Peter James Barry, B.S. University of Illinois, 1963; M.S. University of Illinois, 1964; Ph.D. *Reservation Prices on Credit Use Over Time: Implications for Growth of Cash Grain Farmers.*

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James Dwight Sullivan, B.S. Ohio State University, 1965; M.S. Ohio State University, 1966; Ph.D. *Interregional Flows of Slaughter Cattle, Carcass, Primal, and Retail Beef in the United States.*

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IOWA STATE UNIVERSITY

Mohamed Hassan Askalani, B.S. Cairo University, 1961; Ph.D. *Economic Analysis and Alternative Procedures for Estimating Broiler Production Functions.*

Andrew Gerard Conway, B. Agr. Sc. National University of Ireland, 1961; Ph.D. *An Operational Model of the Relationship Between Liveweight Gain and Stocking Rate for Grazing Cattle, With an Estimated Production Function for Steers, Under Irish Conditions.*

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UNIVERSITY OF KENTUCKY

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LOUISIANA STATE UNIVERSITY

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UNIVERSITY OF MARYLAND

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MICHIGAN STATE UNIVERSITY

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UNIVERSITY OF MINNESOTA

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UNIVERSITY OF MISSOURI

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Russell Bruce Johnson, B.S. University of Missouri, 1962; M.S. Iowa State University, 1965; Ph.D. *Agricultural Loan Evaluation with Discriminant Analysis.*

John Allan Kuehn, B.A. Catholic University of America, 1963; M.S. University of Missouri, 1966; Ph.D. *Highway Impacts on Ozark Incomes and Employment.*

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Arthur L. Wright, B.S. University of Illinois, 1961; M.S. Southern Illinois University, 1962; Ph.D. *The Determinants of Economic Growth in the Missouri Ozarks: 1950–1965.*

NORTH CAROLINA STATE UNIVERSITY

George Konstantinos Christou, B.A. Athens School of Economics and Business Science 1960; M.S. 1967; Ph.D. *Tariff Structure and Effective Protection: The Case of Greek Manufacturing Industries.*

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Berkwood Malcolm Farmer, B.S. 1960; M.S. 1963; Ph.D. *Man-Hour Productivity and Future U. S. Agricultural Adjustment.*

Walter Lee Fishel, B.S. 1956; M.S. Purdue University, 1957; Ph.D. *Uncertainty in Public Research Administration and Scientists' Subjective Probability Estimates about Changing the State of Knowledge.*

Max Ira Loyd, B.S. 1956; M.S. 1963; *Availability and Consumption of Dairy Products in Eastern North Carolina.*

Vasant M. Mehta, B.S. 1951; M.S. Institute of Agriculture Anavd India, 1956; Ph.D. *India's Position in the World Peanut and Peanut Oil Markets.*

Jon Lion Nevins, B.S. Case Institute of Technology 1960; Ph.D. *A Model for Calculating the Optimum Analysis of Mixed Fertilizers.*

James Leslie Pearson, B.S. University of Kentucky 1951; Ph.D. *A Growth Model for Evaluating Investment Alternatives of a Processor of Seasonally Produced Products—An Application to Vegetable Canning.*

Frederick James Prochaska, B.S. Texas Technical College, 1964; M.S. Texas A&M University, 1966; Ph.D. *Opportunity Cost of Time and Other Socioeconomic Effects on Away-from-Home Food Consumption.*

OHIO STATE UNIVERSITY

James Frederick Berg, B.S. Ohio State University, 1965; M.S. Ohio State University, 1967; Ph.D. *The Competitive Position of the Ohio Fed Cattle Industry.*

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Neil Byron Mills, B.S. Cornell University, 1945; B.S. University of Hawaii, 1959; Ph.D. *Production Functions of Small Commercial Farms in the East North Central States, 1966.*

George Raymond Prigge, B.S. University of Kentucky, 1962; M.S. University of Kentucky, 1964; Ph.D. *A Simulation Study of Tenure and Size Relationships of Selected Corn Hog Farms.*

Russell Raney, B.S. University of Michigan, 1943; M.B.A. University of Chicago, 1949; Ph.D. *An Explanation of Changes in the Number of Farms in the U. S., 1910–64.*

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Willard Travis Rushton, B.S. Texas A&M University, 1960; M.S. Ohio State University; Ph.D. *A Test of the Value Concept: The Relationships Between Value Commitments and Political Preference.*

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OREGON STATE UNIVERSITY

Bruce Robert Beattie, B.S. Montana State College, 1963; M.S. Montana State College, 1964; Ph.D. *Economic Efficiency and Distributive Consequences of Interbasin Water Transfers: A Framework for Analysis.*

Leo Joseph Guedry, B.S. Louisiana State University, 1963; M.S. University of Illinois, 1965; Ph.D. *The Role of Selected Population and Site Characteristics in the Demand for Forest Recreation.*

James Boynton Johnson, B.S. Oregon State University, 1964; M.S. Purdue University, 1966; Ph.D. *An Empirical Test of the Use of Expected Marginal Revenue as an Estimate of Total Cost Functions.*

Han Joo Kim, B.A. University of California, 1960; M.A. University of Oregon, 1962; Ph.D. *An Analysis of Investment in the United States Beef Cattle Industry.*

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PENNSYLVANIA STATE UNIVERSITY

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Peter Francis Smith, B.S. Rutgers, 1964; M.S. Rutgers, 1966; Ph.D. *The Influence of Household Characteristics and Income Changes on the Expenditures of Low-Income Households.*

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PURDUE UNIVERSITY

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of Alternative Tillage-Planting Systems on Optimal Farm Organization and Income.

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Raymond Daniel, B.S. University of Kentucky, 1964; M.S. Purdue University, 1967; Ph.D. *An Econometric Analysis of the Farmer Demand for Fertilizer Nutrients.*

Jerald Alan Gunnelson, B.S. University of Wisconsin, 1960; M.S. University of Wisconsin, 1963; Ph.D. *A Study of the Impact of Organizational Changes in Agricultural Commodity Markets on Futures Markets.*

Thomas Lee Guthrie, B.S. Purdue University, 1962; M.S. Purdue University, 1966; Ph.D. *Initial Forward Planning Strategy and Successive Review by the Commercial Feed Firm Utilizing a Static Compacted Linear Programming Model.*

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UNIVERSITY OF TENNESSEE

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TEXAS A&M UNIVERSITY

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VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

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UNIVERSITY OF WISCONSIN

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Discrimination in the Markets for Farm Capital?*

ROBERT TINNEY AND FINIS WELCH

Recent empirical investigations have estimated differential earnings of white and nonwhite labor and education and have interpreted these differences as the combined effects of many forms of economic discrimination. In this paper we use a relatively straightforward model to analyze the implications of discrimination in markets for capital funds. The model is designed to focus upon intermarket flows of goods, in this case white to black, and represents a simple modification of the common excess demand and supply frame of reference. The empirical evidence suggests that earned rates of return do not vary with the race of farm operators as most "theories" of discrimination would suggest. However, there is evidence that rates of return increase with farm size, and since Negroes operate smaller farms it is possible that discrimination has served as an impediment to expansion.

THERE SEEMS to be a popular consensus that in all phases of life there is discrimination against the American Negro. He is presumed to be penalized when he sells his services as a laborer, when he purchases factors and sells products as a producer, when he rents or buys housing, when he attends school, when he attempts to borrow money, and so on, throughout the sphere of his economic and extra-economic activities. Never has a thorough understanding of the processes of discrimination been more relevant than today. If remedial measures are to be undertaken, discriminatory mechanisms must be understood and their impact identified so that a scheme of priorities can be specified. Some piecemeal and stopgap measures in use today are likely to be inefficient and perhaps are ineffective, and analyses of this type can help to reorder priorities for remedial measures.

In recent years we have made considerable progress in developing a taxonomy that permits a fuller understanding of the ramifications of economic discrimination. The pathbreaking work in the area was that of Gary Becker [1], who pointed out the implications of a "taste for discrimination" and made us aware that not only will discrimination cost those discriminated against, but, barring universal collusion, it will also cost the discriminators. One result of Becker's taxonomy is that in many instances one is hard pressed to explain the existence of discrimination in a reasonably competitive market. For example, how can there be discrimination in housing if possibilities for new construction are available? Too, if there is discrimination in loan markets, why would anyone interested in maximizing revenue loan money to whites when Negroes are willing to borrow at higher interest rates? And would we not expect this propensity to loan to Negroes to force interest rates charged to Negroes and whites toward equality? Here, in order to "explain" differentials among Negroes and whites, it is usually necessary to introduce the idea of the psychic discount. A (white) person will not loan funds at equal rates to Negroes and whites, nor will he sell (or rent) a house at the same price if there are psychic costs involved in associating with Negroes. However, as Welch has indicated [9], the use of psychic discounts to explain price differentials makes it necessary to distinguish between personalized and impersonal products or services. As an example, it is easy to see how there can be discrimination against labor services since these cannot be divorced from the laborer providing them. But it is not easy to understand discrimination against an impersonal product. How meaningful is a psychic discount if the producer of a product cannot be identified? Thus, Welch has pointed out that when the product (or factor) is impersonal, any psychic discount must be attributed to association between buyer and seller during the time the product is being transferred. Since the product is impersonal, the seller's race is not an intrinsic characteristic and is irrelevant after the transaction has occurred. For this reason a discount in the value of an impersonal product (because of nonpecuniary costs occurring during the transaction) introduces the possibility of intermediation.

Although in this case the role of the intermediary is obvious, it is convenient to specify his function somewhat more formally, since in doing so we will provide the format for the

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ROBERT TINNEY *is with the Pennsylvania State University.* FINIS WELCH *is with the National Bureau of Economic Research.*

analysis used in this paper. Let us suppose that a Negro sells an impersonal product to a white for a price of P and that, because of the psychic costs involved, he acts *as if* he has received only $P(1-\pi_s)$, where $P\pi_s$ is the equivalent monetary value of the seller's psychic discount. Furthermore, assume that the buyer who pays price P acts as if the price is actually $P(1+\pi_b)$, where $P\pi_b$ is the monetary equivalent of the buyer's psychic cost. Now the mutual discrimination drives a wedge between the consumer's and producer's effective prices that is simply the sum of the monetary equivalent discounts, $P(\pi_s+\pi_b)$. It is possible that π_s can be zero if the seller is indifferent toward the buyer, or even negative if he views the buyer "charitably." The same may be true of π_b with respect to the buyer's attitude toward the seller; nevertheless, we assume that the sum of $\pi_s+\pi_b$ is positive. In this case, suppose that an intermediary appears. If he can effect the product's transfer between seller and buyer at a cost lower than $P(\pi_s+\pi_b)$, he will find it profitable to do so.[1] Even in the absence of discrimination most products require intermediation as a normal market function in circumventing barriers of distance and information. Because of this it is likely that the process of providing a buffer between antagonistic buyers and sellers may not increase normal transaction costs. This would be especially true if there were a relatively large supply of persons who neither affect nor are affected by those with whom they trade. Such persons have a comparative advantage as intermediaries and, if their supply is large enough, their characteristics are prerequisite to employment as an intermediary.

All of this implies that discrimination against the producers of impersonal products may be less likely than is commonly assumed. The potential for discrimination may be more important in determining the characteristics of "middlemen" than in increasing the spread between producer and consumer prices. But the same is true of impersonal factors of production, and that is why we are somewhat dubious about asking the question: Is there discrimination in the supply of funds to Negro farm operators?

The Basic Model

We begin with a fully democratic model of interacting discrimination between suppliers and borrowers of capital funds. The model is democratic in the sense that both Negroes and whites are potential discriminators. We assume that at any given interest rate, some Negroes and whites will be lenders while others of each group will be borrowers. Whether a particular individual is a borrower or a lender will depend upon his subjective evaluation of the marginal productivity of capital used on his farm, the market rate of interest, and the "asset position" of the farmer. If the market permits him to loan some of his funds at a higher rate of return than he believes he can earn by using them himself, the presumption is that he will lend and that if conditions are reversed, he will be a borrower.

Because of the possibility of discrimination, it is not obvious a priori how supply and demand functions should be specified. The problem arises inasmuch as the level of demand is affected at least potentially by the race of the seller and the level of supply is affected by the buyer's race. To avoid these ambiguities we specify demand and supply functions separately for Negroes and whites on the assumption that transactions are intraracial; and when transactions are interracial, we explicitly consider shifts in the respective demand and supply functions. Thus, in this pseudo-segregation of the market, the demand function of whites is presumed to carry the interpretation that it represents a schedule of quantities demanded at given interest rates ***when the capital is supplied by whites***. Similarly, the white supply schedule connotes "supplied to whites," just as the Negro demand and supply schedules refer to transactions within the "Negro market" only.

Discrimination is introduced as a shift in a particular demand or supply schedule. If white borrowers have a relative preference for funds borrowed from whites, they are presumed to act as though funds borrowed from Negroes are obtained at higher interest charges than they actually are. This relative preference can be expressed as a downward shift in the white demand functions as viewed by Negro suppliers. It follows that if white suppliers have a relative preference for lending to whites, they will act as if interest payments received from Negroes are lower than they are in fact. Such a reaction is expressed as an upward shift in the supply of white capital as viewed by Negro borrowers. The discriminatory mechanism is fully operable once the possibility of Negro discrimination against whites is added. We assume simply that

[1] Notice that the intermediary's cost will include any psychic discount resulting from his association with the buyer and seller, regardless of which participant is affected.

as viewed by whites, respectively demanders and suppliers, the supply function of Negro capital lies above its segregated market equivalent and the demand function of Negroes for capital lies below its equivalent in the Negro market.

Given the potential for discrimination on the part of all suppliers and demanders, in order to determine the market's equilibrium it is necessary to realize that if discrimination does in fact exist, funds will not flow simultaneously from the white to the Negro market and from the Negro to the white market. If whites lend to Negroes, we assume that the interest rate paid by Negro borrowers must be sufficiently greater than the rate paid by whites so that suppliers can be compensated for their psychic costs. It also follows that if Negro demanders discriminate against whites they will pay lower rates for funds supplied by whites than for funds supplied by Negroes. Thus, if whites lend to Negroes, Negroes will not lend to whites since the interest rate they can receive from Negroes will exceed that offered by white borrowers.

In Figure 1 we have depicted a market for capital funds in which both whites and Negroes are (potential) discriminators. Since in the presence of discrimination we would not expect funds to be loaned simultaneously by whites to Negroes and by Negroes to whites, we have initially assumed an artificial segregation of the market into white and black components, parts (a) and (b), respectively, in Figure 1. Assuming that whites will supply funds to Negroes, we derive an excess demand function of Negroes for funds and an excess supply function of funds from whites, part (c) in Figure 1. More specifically, part (a) indicates the segregated white market with demand D_w and supply S_w. If the markets were fully segregated, the equilibrium interest rate in the white market would

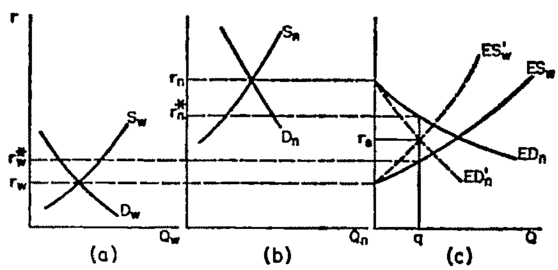

Figure 1. A hypothetical specification of discrimination in a market composed of two groups in which some members of each group are suppliers and demanders

be r_w. Similarly, in part (b), D_n and S_n indicate the respective demand and supply functions for the Negroes with a segregated equilibrium interest rate, r_n. Since by assumption r_n exceeds r_w, if the market is integrated whites will lend to Negroes.

Two steps are required to derive the supply of funds loaned to Negroes by whites. First, we ignore discrimination and consider the quantity of funds that would leave the segregated white market at each interest rate. That quantity is positive only for rates in excess of r_w and is given as $ES_w = S_w - D_w$, i.e., the excess quantity supplied over that demanded at each interest rate. The second step provides for discrimination by white suppliers by introducing an upward shift in the excess supply function from ES_w to ES_w'. The demand of Negroes for white funds is obtained in a similar manner. An excess demand function is derived from the segregated Negro market and then shifted downward from ED_n to allow for discrimination by Negro demanders. At the quantity q in part (c) the integrated market attains an equilibrium. There are now three equilibrium interest rates, r_w^* for whites borrowing from whites, r_n^* for Negroes borrowing from Negroes, and r_e for Negroes who borrow from whites. Each is an equilibrium since a Negro who borrows from a white at a rate of r_e will behave as though the rate were r_n^* and whites who supply funds to Negroes at r_e act as if they receive only r_w^*.

The Empirical Specification

We assume that farm operators employ just enough capital so that the rate of return earned on the farm is equal, at the margin, to the market rate of interest. This follows from a joint assumption that farmers are maximizing profit (or their psychic equivalent) and that within each segregated market, the interest rate is the same for borrowing and lending and is therefore both the explicit cost of capital for borrowers and the implicit or opportunity cost for those who use their own capital. An added assumption is that the capital market is integrated, with whites lending to Negroes. Thus, in the presence of discrimination there is a difference in the cost of capital as viewed by Negro and white farm operators, and the interest rate used for decisions by Negro farm operators will exceed the rate used by white farmers. (In Figure 1 these rates are r_n^* and r_w^*, respectively.) It follows that by observing earned rates of return on farm capital we can, at least in principle,

"test" for the presence of discrimination. For example, if the earned rate of return on capital employed by Negro operators exceeds that of whites, there may be discrimination in farm capital markets; but if there is no difference in earned rates of return, the implication is that there is no discrimination.

It is important that an observed difference in rates of return is interpreted as the combined effect of discrimination by borrowers and lenders and cannot be construed as evidence that one particular group or race is discriminating against another. Evidence of discrimination by lenders belonging to a specific group must be obtained directly by comparing the rates at which persons in that group loan to other members of their group and to persons of other groups. Likewise, evidence of discrimination by borrowers requires observation of the relationship between the borrowing rate and the lender's race.

In this paper rates of return earned by Negroes and whites on capital invested on farms are taken from regression estimates of the rate of return earned on operator-owned farm land and buildings.

The data used are taken from a matched sample of the 1960 Sample Survey of Agriculture [6] and the 1960 Census of Population [7]. The matched sample contains detailed information on 1,929 farm operator families who were selected on the basis of a stratified sample in which the sampling frequencies increase with farm size. The sampling ratios ranged from 1 in 9,999 on the smallest farms to 1 in 548 on the largest. Within the sample there are 733 farm operators in the South Atlantic, East South Central, or West South Central agricultural divisions who were 25 years old or over in 1960, who did not have an urban residence, who were characterized as either Negro or white (other nonwhites eliminated), and who had worked sometime during the last decade. Our analysis is restricted to these persons. They include 132 Negro and 601 white farmers, of whom 60 Negroes and 496 whites own some of the land on their farm. Among Negroes who own land the average value of land and buildings owned is $6,300; for whites the corresponding value is $21,500.

Other relevant characteristics of the sample population—the distribution of operator-owned land and buildings, the distribution of years of school completed, and the age distribution—are provided separately for Negro and white farm operators in Appendix Table A. To estimate earned rates of return on farm capital we have used an accounting definition of income in which business income[2] is viewed as the sum of the income to the operator's labor and the return to his invested capital.

The return to capital is considered as the average rate of return times the capital value.[3] The return to the operator's labor is assumed to be a function of his schooling and its quality, his age, and other variables.

The preceding analysis is couched wholly in terms of discrimination that results in a difference in the earned rate of return between Negro and white farm operators. It is important that returns to capital may vary, not only between races, but because of economies of scale and other transitory conditions permitting windfall profits or quasi-rents that may be correlated with capital investments. If rates of return decrease with farm size, there is no analytical problem. The type of discrimination described here simply results in Negro-owned farms whose most efficient size is smaller than it would otherwise be, and these farms will have a higher "equilibrium" rate of return. On the other hand, if rates of return increase with size, disscrimination may serve as an impediment to expansion. Farm sizes in which the marginal productivity of capital is increasing are not efficient unless marginal capital costs are increasing even more rapidly; otherwise it will "pay" firms to expand and exhaust scale economies. But suppose that, because of discrimination, the supply price of funds to Negroes is above the maximum rate of return that can be earned at any farm size. Discrimination of this type amounts to a refusal to loan. Now suppose that there are in essence two capital markets—one formal, the other informal. In the informal market funds are obtained from family, friends, and perhaps government agencies (Farmers Home Administration) at subsidized rates. If the formal market excludes Negroes because of

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[2] The Census defines total income as the sum of wage and salary income, business income, and other income. The definition of wage and salary income is obvious. Business income is the combined return to labor supplied by the entrepreneur and the return to his capital invested in the business. Other income includes transfer payments and income to capital not invested in a firm operated by its owner.

[3] The return to capital of value C is sometimes defined as $R=(r+\delta)C$ where r is the net rate of return and δ is the rate of depreciation. (If the value of capital has appreciated, δ will be negative.) Our estimates are of gross rather than net rate of return.

a prohibiting charge and the only access to funds is through informal markets, we would have no a priori reason to expect any relationship between realized rate of return and the race of the farmer, over all scale classes; but we would expect that within each class nonwhites would earn higher rates of return as they substitute other inputs for the relatively scarce capital. Bear in mind that rates of return increasing with farm size are prerequisite to this sort of discrimination.

The explicit form of the income equation is given as

$$Y = r_{ij}C + S_{ik} + A_l + R_m + T + u$$

where

Y is business income in 1959.

C is the estimated value of operator-owned farm land and buildings.

r_{ij} is the average rate of return on owned land and buildings earned by farm operators of the ith race, Negro or white, and the jth farm scale class. Three scale classes are used: (1) commercial farm (sales in excess of $5,000; classes for larger farms were not specified because there are very few Negroes in the sample with sales exceeding $5,000); (2) small farm (sales less than $5,000 but not a part-time farmer); (3) part-time farmer (sales less than $2,500 and 100 or more days worked off the farm in 1959). Notice that with the race-scale interaction there are six separate rates of return to be estimated.

S_{ik} is the predicted income of a person (who is 45–54 years old, lives in the South Atlantic division of the South, and is not a "cropper") who is of the ith race and the kth schooling class and owns no land or buildings. The schooling classes refer to years of school completed and correspond to 0–4, 5–11, 12–15, and 16 or more years of school completed. There are no Negroes in the sample who have completed 16 or more years. The interaction between race and schooling (providing 7 distinct coefficients, 4 for white schooling and 3 for Negro) is required because of the possibility of quality differences in Negro and white schooling.

A_l is an adjustment in predicted income for persons who are not 45–54 years old. For the lth age class (there are five, 24–34, 35–44, 45–54, 55–64, and 65 or more) A_l is interpreted as the change in income as the operator's age changes from 45–54 to that of the lth class.

R_m is an adjustment in predicted income for persons who do not live in the South Atlantic region (there are two others, East and West South Central). Regional coefficients are estimated as an allowance for transitory phenomena that are regionally correlated, such as weather. The use of a single year, 1959, for the income observation requires allowances for transitory components in income.

T is an adjustment in predicted income for persons who are neither full nor part owners of the farms they operate, i.e., who are croppers or other tenants. A cropper is a tenant who works under a crop-share contractual arrangement. For a given share agreement to be viable, it must result in the long run in operator (and landlord) income similar to that resulting from ownership or other tenant arrangements. Yet, in any given year the inflexibility of the contract may result in windfall losses or gains for the farm operator. In the long run the average windfall should be zero.

u is an unobserved measure of the individual characteristics that affect a person's income and are not caught in the above crude measures.

Although this particular functional form is obviously designed for tests of hypotheses about the alternative values of r_{ij}, it is important to be aware that such tests are severely limited in terms of their general validity. As we see it, there are two major shortcomings. The first is that the model refers to only one year, 1959. For residual income recipients, such as farm capital, there are likely to be considerable transitory components in realized rates of return, so that observations for a single year may be subject to large biases. That these transitory phenomena would be correlated with the race of the farm operator appears to be unlikely; but we would nevertheless prefer evidence for several periods with more fluctuation in "other things." The second major disadvantage is that the functional specification is designed to estimate *average* rates of return over large intervals. The "theory" of the earlier section is couched wholly in terms of marginal rates of return. We

do not have adequate information about the relationship between marginal and average returns for farm capital; so, in the absence of an alternative, we selected this simple form which implies equality between the average and margin. Again, divergence between average and marginal rates of return can bias our results.[4] On the plus side, implicit evidence of this type, taken directly from observations of income and the ownership of capital, is net of risk and related adjustments and is therefore not subject to biases that would ordinarily thwart direct comparisons of loan markets.

The Results

The equation specified above is first estimated and used as our maintained hypothesis that earned rates of return to farm capital vary both with the race of the farm operator and the scale of the farm. Against this we test the alternatives that rates of return vary neither by race nor by scale, that they vary by scale class but not by race, and that they vary by race but not by scale class. Estimates of the maintained (equation 1) and alternative hypotheses (equations 2–4) are provided in Table 1. Notice that the maintained hypothesis allows for six distinct estimates of rates corresponding to the three scale classes for each of the two specifications of operator's race. In comparison, under the alternative hypotheses fewer rates are estimated as various constraints are imposed.

In the regression equation 1, estimated rates of return earned by Negroes exceed those earned by whites in the two scale classes corresponding to the largest farms. This is, of course, consistent with discrimination in capital markets, but a question of the significance of these differences remains. Regression equation 2 imposes the constraint that within each of the scale classes Negroes and whites earn the same rate of return. Equation 3 allows for differences in rates of returns by race but constrains the estimates so that returns do not vary by scale, and equation 4 permits the estimated rate of return to vary neither by scale class nor by the race of the operator.

To "test" for the existence of either race or scale effects, equation 4 is compared with equation 1. The comparison yields a computed $F(5,713)=2.31$ with associated 0.05 critical value of 2.22. Thus, there is weak support for the hypothesis that rates of return vary either by scale class or by race, or by both. To see whether the difference can be described as "scale only" or "race only," equations 3 and 2 are then also compared with equation 1.

The comparison of 3 with 1 yields a computed $F(4,713)=3.33$ with associated 0.05 critical value 2.38. Thus, we cannot accept the hypothesis imposed by equation 3 that rates of return are independent of farm scale. Alternatively, the comparison of equation 2 with 1 yields a computed $F(3,713)=0.16$ with 0.05 critical level 2.61 so that the hypothesis that rates of return, within each scale class, are the same for Negroes and whites is accepted. Equation 2 is therefore our best estimate.

The evidence is that rates of return vary with farm size and that they increase as size increases. Negroes earn lower returns than whites, not because returns differ within scale classes, but because Negroes operate smaller farms. Is this evidence of discrimination? The answer is a somewhat timid "No, but discrimination is consistent with the observation." Strong evidence of discrimination requires evidence of Negroes earning higher returns than whites. If returns increased with farm size and capital were more of an inhibiting factor for Negroes (i.e., there is discrimination) in their attempts to expand, we would expect to see Negro operators "pushing harder" against the capital constraint, that is, earning higher returns within size classes. This evidence is missing. On the other hand, the evidence is consistent with an hypothesis of no discrimination, but this interpretation presents the question of why Negro farms have not attained the same "size" as white farms. What we can conclude is that the market has not operated to permit an observation of the kind of discrimination described in the model presented earlier. This may be either because there is in fact no discrimination or because discrimination has been more "prohibiting" in the sense that charges precluded borrowing rather than being merely "slightly" higher rates. The type of data described here cannot go further in breaking into this "box," but let us speculate.

Because of intermediation possibilities we find an argument in favor of discrimination in capital markets to be unconvincing, and the data *are* consistent with this hypothesis. Why then have Negro farms not expanded to capi-

[4] Of course, if the average rate of return function has equal elasticity for Negro and white farm operators (within the appropriate intervals), then the respective marginal returns are each in the same proportion to the average. In this case, the comparisons retain their validity.

Table 1. Regression estimates of factors contributing to the business income of Southern farm operators, 1959[a]

Factor	Regression number (1)	(2)	(3)	(4)
	Race and scale specification used in equation			
	Full race-scale interaction	Scale differences only, race differences suppressed	Race differences only, scale differences suppressed	Both race and scale differences suppressed
	Rates of return to owned land and buildings (percent)			
Race and scale				
All farmers				3.20 (0.25)
Class 1		3.40 (0.25)[b]		
Class 2		2.00 (0.78)		
Class 3		0.30 (0.90)		
White			3.20 (0.25)	
Class 1	3.40 (0.25)			
Class 2	2.00 (0.78)			
Class 3	0.30 (0.94)			
Negro			1.20 (2.70)	
Class 1	4.60 (18.55)			
Class 2	5.40 (5.40)			
Class 3	−0.30 (2.91)			
	Predicted business income (exclusive of return to land and buildings) of full or part owners aged 45–54 in South Atlantic region (dollars)			
Race and years of schooling				
White				
0– 4	510 (290)	530 (290)	470 (290)	460 (290)
5–11	1,080 (210)	1,090 (210)	1,020 (210)	1,020 (210)
12–15	1,140 (270)	1,160 (270)	1,080 (270)	1,080 (270)

[a] The observations (733) are for individuals as reported in the matched sample. The definition of variables is straightforward, except for business income. For each observation business income is reported by income intervals, but "expanded" business income and "final weight factor" (the inverse of the sampling proportion) are also reported. In all cases the ratio of expanded business income to the final weight factor falls within the reported interval and is therefore taken as a point estimate.

[b] Standard errors are in parentheses.

Table 1. continued

Factor	Regression number (1)	(2)	(3)	(4)
	Race and scale specification used in equation			
	Full race-scale interaction	Scale differences only, race differences suppressed	Race differences only, scale differences suppressed	Both race and scale differences suppressed
16 and over	3,490 (520)	3,500 (520)	3,140 (510)	3,140 (510)
Negro 0–4	290 (360)	340 (340)	340 (350)	290 (350)
5–11	310 (350)	380 (310)	390 (340)	300 (310)
12–15	220 (990)	350 (950)	420 (980)	300 (960)
	Adjustment in predicted business income for age, region, and tenure status (dollars)			
Age 25–34	−240 (290)	−250 (290)	−250 (290)	−250 (290)
35–44	− 70 (220)	− 70 (220)	−120 (220)	−122 (220)
45–54	—	—	—	—
55–64	−320 (220)	−330 (220)	−380 (220)	−380 (220)
65 and over	−610 (240)	−610 (240)	−640 (240)	−630 (240)
Region South Atlantic	—	—	—	—
East South Central	−190 (190)	−190 (190)	−250 (190)	−250 (190)
West South Central	360 (190)	360 (190)	310 (190)	300 (190)
Tenure status Full or part owner	—	—	—	—
Cropper or other tenant	570 (210)	540 (210)	650 (210)	680 (210)
Residual sum of squares	3,060	3,062	3,117	3,119
Degrees of freedom	713	716	717	718
R^2	.297	.296	.283	2.283

talize upon scale economies? We feel that two factors are important here. First, the capital base is smaller so that loans would be made on less equity and would therefore be riskier. Second, rising land values for those with land, coupled with increasing nonfarm wage rates especially in the North, have eased exit from agriculture. Instead of expanding to capitalize on scale economies, capital gains are "cashed in" to ease entry into a nonagricultural, typically non-Southern life.

Our "best" estimate of the rate of return t

farm land and buildings in the South is 3.2 percent, which is essentially the same as the 3.0 percent rate of return realized by farmers on "owned assets" in 1960.[5]

However, as noted above, this estimated rate is gross of both depreciation and appreciation. Of the total value of land and buildings, about 32 percent is accounted for by buildings. Assuming a rate of depreciation for buildings of 5 percent annually and an annual rate of appreciation for agricultural land of 7 percent, the net rate of return to farm capital based on the estimated gross rate is 6.4 percent.

Although we find no direct evidence of discrimination in capital markets, there may be some indirect evidence in the estimated income-schooling profiles. Notice that while the income of white farm operators is sharply responsive to added schooling, the income of Negro farmers remains constant as additional schooling is acquired. *To the Negro farm operator in the South schooling is of no monetary value.* As we see it, there are two possible explanations of this phenomenon. First, there may be discrimination in farm capital markets of the type that simply prohibits loans to Negroes. Suppose that farm capital is relatively complementary to the skills acquired in school so that for schooling to be profitable the farm firm would have to be relatively capital intensive. Suppose further that Negroes are simply unable to borrow (from whites) at any price but that whites face a perfectly elastic supply. In this case we would have no prior expectation about a comparison between Negroes and whites of earned rates of return, but would expect to find that for Negroes rates of return are an increasing function of the operator's schooling. In the sample analyzed here there are insufficient observations to test this hypothesis together with those presented above.

An alternative explanation of the "flat" income-schooling profile for Negro farmers is that the skills they acquire in school are irrelevant in farming. This could be true either because of the inferior quality of the Negro schools or because of discrimination through things that are potential complements to schooling. An obvious example is that offered above: An inability to expand the firm restricts the value of schooling. We feel that the discriminatory practices of the Federal Extension Service (prior to the Civil Rights Act of 1964) may have been of even greater importance. Welch [10] has provided evidence suggesting that in agriculture the productivity of more-schooled, as compared with less-schooled persons, is related to the "innovative environment," which is assumed to be determined largely by the level of research and extension activity within a state. The evidence suggests that the more rapid is the rate of technical change, the greater will be the relative productivity of the well-educated person. One consequence of the segregation of the Extension Service may have been that of effectively isolating Southern Negroes from technical change in agriculture. In a special report by the U. S. Commission on Civil Rights [4], the potential for this isolation is made obvious.

The remaining estimated parameters are of less interest. The age-income profile suggests that, in this cross section, business income is maximized between 45 and 54 years of age. Persons 25 to 34 years old earned an estimated \$250 less than persons aged 45 to 54 (in 1959); the farm operator 35 to 44 years of age earns \$70 less; and so on for the remaining age groups. The coefficient for "croppers" indicates that in 1959 the contractual arrangement between croppers and landowners was favorable (+\$540) to the cropper. Recall that this phenomenon should be transitory and that over several years we would expect the average windfall associated with a particular institutional arrangement to be (approximately) zero. The discrepancies in business income among the three divisions are also presumed transitory but may reflect disequilibria in labor markets or other related phenomena.

Summary and Conclusions

We have attempted to provide a logically consistent mechanism for obtaining evidence of racial discrimination in farm loans. The model is simple and represents an extension of the standard excess supply and demand framework —one we feel to be useful in the analysis of a wide range of discriminatory phenomena. Our empirical evidence has several limitations, and we would have preferred more extensive evidence of earned rates of return based on more than one type of investment and on more than one year. Nonetheless, we believe that the results are suggestive.

The potential for intermediation in the presence of discrimination against impersonal products and factors raises the question: How

[5] See [5].

can discrimination exist in these markets? Our data suggest that it may not. The observed fluctuations in rates of return are certainly consistent with purely random behavior at generally accepted confidence levels. These data suggest that the investigator concerned with Negro-white income differentials in farming might well concentrate on differences in the productivity of schooling instead of capital markets.

Appendix

Table A. Characteristics of southern farm operators in matched sample of the U. S. census of population and the sample survey of agriculture, 1960

Number of farm operators by	White	Negro
Years of school completed		
0– 4	81	59
5–11	375	68
12–15	125	5
16 and over	20	0
Age		
25–34	58	15
35–44	129	32
45–54	166	34
55–64	144	25
65 and over	104	26
Valued of capital owned (thousands of dollars)		
1– 4,999	97	36
5,000– 9,999	122	14
10,000–19,999	119	8
20,000–29,999	63	1
30,000 and over	95	1
Scale of farm operated		
Commercial	359	80
Part time	165	34
Part retirement	77	18
Region		
South Atlantic	200	58
Eastern South Central	193	46
Western South Central	208	28
Tenure status		
Full or part owner	496	60
Cropper or other tenant	105	72

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The Relative Share of Labor in United States Agriculture, 1949-1968*

THEODORE P. LIANOS

The sources of change in the relative share of labor in the American agricultural sector are examined within the framework of neoclassical production theory. It is found that the observed decline in labor's relative share is due to the increasing capital-labor ratio adjusted for changing efficiency of factors and to the elasticity of substitution which is greater than unity. It is also found that the efficiency of capital is increasing faster than that of labor and that technological change in American agriculture has been labor-saving.

THE RELATIVE share of labor in U. S. manufacturing has been relatively constant over the past century. This relative stability was so surprising and unexpected on theoretical grounds as to cause Keynes [15] to call it "a bit of a miracle." Others have thought of this stability as an economic law of modern capitalism.[1] However, more recent studies by Solow [19], Kravis [16], and Ferguson and Moroney [9] have shown that for the postwar period the relative share of labor in U. S. manufacturing has increased. An entirely opposite picture emerges in the U. S. agricultural sector. Estimates supplied by Ruttan and Stout [18] clearly indicate that for the 1944–1957 period labor's relative share has been declining. Their estimates for the 1925–1944 period appear to vary around a mean value of 35.5, with no apparent trend; in 1925 the relative share of labor was 37.8, and in 1933 and 1944 slightly less at 36.1. Thus it appears that although in the prewar period the relative share of labor in agriculture showed a relative constancy, as in manufacturing, it has followed an opposite direction in the postwar period.

In this paper we attempt to do three things: (1) to describe the behavior of the relative share of labor in U. S. agriculture for the period 1949–1968; (2) to investigate the sources of change in the relative share of labor for the same period; (3) to compare our findings with those of other researchers for American nonagricultural industries. The analysis is performed within the theoretical framework of neoclassical theory of production and distribution.

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[1] This statement is found in Dobb [5, p. 19].

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Relative Share of Labor in American Agriculture: 1949-1968

Estimation of labor's relative share

Estimation of the relative share of labor was based on the definitional formula of the relative share, that is, $S_L = (W \cdot L)/Y$ where W = wage rate, L = man-hours, and Y = value of total agricultural output. The wage rate was measured by the composite rate per hour as reported in [21]. The labor input was measured by the number of man-hours as reported in [20]. This measure consists of labor required for all farmwork, and it includes farmers and unpaid family workers.[2] The measure of total agricultural output used includes cash receipts from farm marketings, household consumption, and net change in farm inventories, as reported in [20]. To the extent that intraindustry exchange takes place and/or that farm business buys farm inputs from nonfarm business, this measure of output includes double counting and thus leads to underestimation of the relative share of labor. The contribution of intraindustry exchange has probably been declining, primarily as a result of farm integration; thus the underestimation due to intraindustry exchange is declining. The contribution to double counting of nonfarm-farm business transactions cannot be determined. It is suggested, however, that double counting from this source may be increasing. This suggestion is based on Dovring's finding [6, p. 12] that the amount of labor input embodied in the nonagricultural output used by agriculture has remained relatively constant in the period 1920–1960. Given that the productivity of labor has increased, it follows that double counting has probably increased. Notice that the two sources of double

[2] In estimating the wage bill (W·L) farmers and unpaid family workers are assumed to receive the wage rate of hired labor as remuneration for their labor supply. Some of the problems resulting from this procedure of imputing wage earnings to farm operators and unpaid family workers are discussed by Ruttan and Stout [18, p. 61].

counting have opposite effects on the estimate of the relative share of labor.

In connection with the estimate of the relative share of labor there are two points to be stressed. First, even if the behavior in labor's relative share is not exactly as pictured in Figure 1, it is certainly declining, and this is what is important in attempting to explain the sources of change. The wage bill, according to our estimates (Appendix A), has been declining throughout the 1949–1968 period. Also, independent estimates by Fuller and van Vuuren [10, Table 5] show a declining wage bill for agricultural labor. Since the value of total agricultural output is not declining during the same period, the decline in the relative share of labor is established. Second, the estimation of the parameters that are crucial for the explanation of the changes in the relative share of labor, namely, the elasticity of substitution, capital-labor ratio, and factor productivity changes, does not depend on the estimate of the relative share of labor. In a sense the development and estimation of the model that is presented in the next section provides a check on the validity of the estimate of labor's relative share, since contradiction would arise if the model predicts positive changes and the data show negative changes. Such a contradiction does not arise in this paper.

However, in order to increase our degree of confidence in the finding that the relative share of labor has decreased dramatically throughout the period covered in this study, we have estimated labor's relative share, S_L', as the ratio of wage bill to value added. Value added (VA) has been estimated by $VA =$ total agricultural output—(farm operating expenses—expenses for hired labor—livestock expenses)—property taxes. Livestock expenses have been subtracted from the operating expenses because we do not view this item as an operating expense similar to the other items, since its effect on total output is not exhausted in the year the expenditure is made. The difference, however, on the estimate of the relative share of labor is negligible.

These two estimates of the relative share of labor (presented in the following section), one

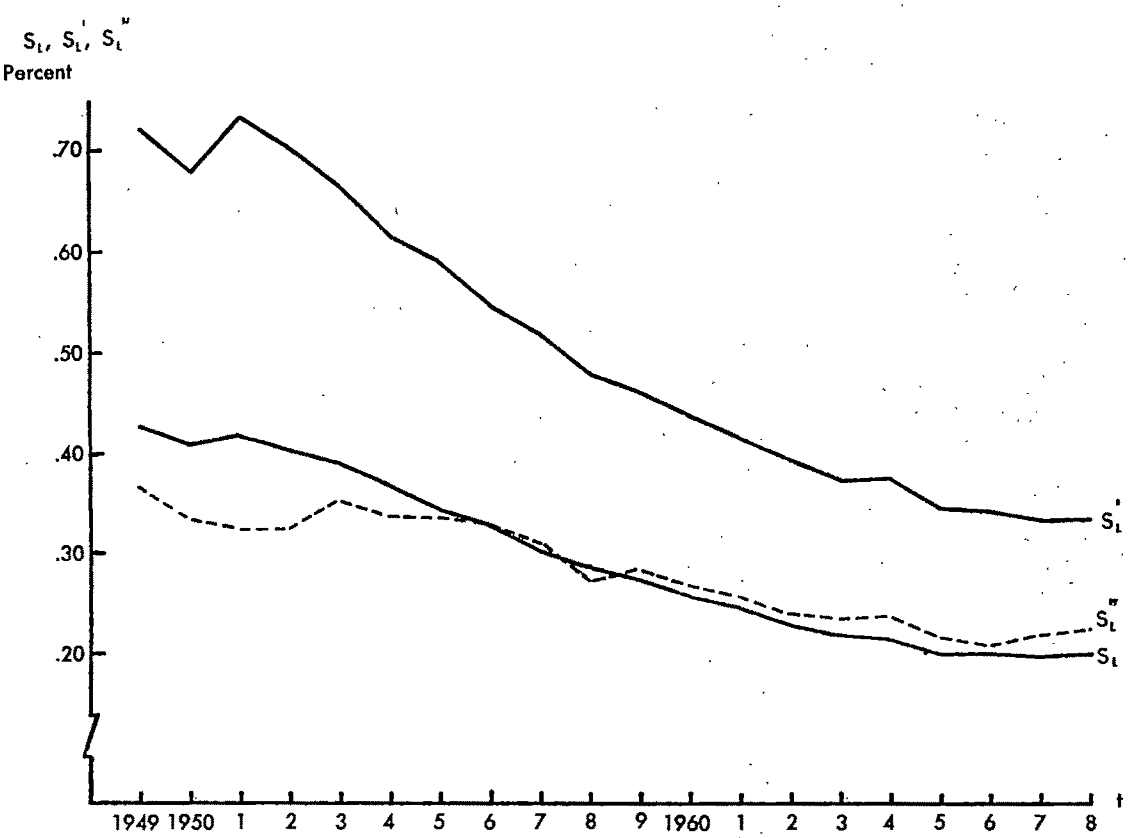

Figure 1. Relative share of labor in U. S. agriculture

based on gross output and one based on value added, were obtained by deflating wage rate estimates by the index of prices paid by farmers (1957–59 = 100) and output estimates by the index of prices received by farmers (1957–59 = 100). Admittedly this deflationary procedure is not the ideal way to transform the data into real terms, and an argument has been made for the estimation of the relative share of labor in current terms. Thus, a third estimate, S_L'', has been obtained by using money wages and by dividing the resulting wage bill by gross output in current prices. This estimate is also presented in the next section.

Behavior of labor's relative share

The estimates of the relative share of labor are presented in Table 1 and plotted against time in Figure 1. The lines labeled S_L and S_L' are based on deflated data, and the dotted line labeled S_L'' is based on data evaluated at current prices. All three measures show that the share of income allocated to labor has been declining. As expected, the use of value added rather than gross output changes the level of the relative share of labor but does not affect the direction of the changes. Use of current rather than deflated data changes the slopes of the curves only slightly. It also appears that for the last four years the relative share of labor has remained practically constant and in fact has increased when measured by S_L''. However, it is too early to assign any significance to this constancy or rise. Because the three alternative measures of the share of labor (S_L, S_L' and S_L'') show quite similar trends, an analysis of changes in shares based on any of the three series would produce similar empirical results. Only S_L will be used in the following analysis.

Table 1. Estimates of the relative share of labor and proportional change: U. S. agriculture, 1949-1968

Years	S_L	$\Delta S_L/S_L$	S_L'	$\Delta S_L'/S_L'$	S_L''	$\Delta S_L''/S''$
1949	.4271		.7223		.365	
1950	.4052	−.0519	.6787	−.0603	.333	−.0876
1951	.4153	.0249	.7337	.0810	.322	−.0330
1952	.3979	−.0418	.7036	−.0410	.321	−.0031
1953	.3880	−.0248	.6652	−.0545	.351	.1059
1954	.3606	−.0706	.6131	−.0783	.336	−.0427
1955	.3416	−.0526	.5783	−.0567	.334	−.0059
1956	.3279	−.0401	.5451	−.0574	.327	−.0209
1957	.3027	−.0768	.5147	−.0557	.306	−.0642
1958	.2820	−.0683	.4754	−.0763	.271	−.0816
1959	.2718	−.0361	.4601	−.0321	.280	.0332
1960	.2579	−.0511	.4361	−.0521	.266	−.0500
1961	.2442	−.0531	.4102	−.0593	.254	−.0451
1962	.2294	−.0606	.3909	−.0470	.238	−.0672
1963	.2177	−.0510	.3712	−.0754	.233	−.0210
1964	.2152	−.0114	.3733	.0056	.237	.0171
1965	.1996	−.0724	.3441	−.0782	.215	−.0928
1966	.1989	−.0781	.3420	−.0061	.206	−.0418
1967	.1970	−.0095	.3323	−.0283	.219	.0631
1968	.1999	.0101	.3337	.0042	.224	.0228
Mean	.294	−.0428	.501	−.0404	.282	−.0218
standard deviation		.0264		.033		.0878

Sources of Change in the Relative Share of Labor

Theoretical considerations[3]

Basic assumptions.—Since we are interested in aggregate magnitudes, we assume an aggregate production function with the marginal product of each factor increasing at a decreasing rate. Specifically, agricultural output is given by

$$Y = F(C, L; t)$$

where F is homogeneous of first degree in the factors of production capital (C) and labor (L). Also $F_C > 0$, $F_L > 0$, and $F_{CC} < 0$, $F_{LL} < 0$.

It is also assumed that $F_C = r$ (r = return to capital), and $F_L = W$.

Time is also included in the production function to allow for technological change. The form of F is specified later.

Bias and rate of technological change.—Using Hick's approach, the bias of technological progress is defined as the proportional change in the ratio of marginal products of capital and labor, i.e.,

$$B = \left[\frac{\partial\left(\frac{F_C}{F_L}\right)}{\partial t}\right] \div \left(\frac{F_C}{F_L}\right). \tag{1}$$

Remembering that F_C and F_L are functions of time, and after some simple manipulations, the bias is given by

$$B = \left(\frac{\partial F_C}{\partial t} \div F_C\right) - \left(\frac{\partial F_L}{\partial t} \div F_L\right). \tag{2}$$

The rate of technological progress is defined as $R = \partial F/\partial t \div F$. Remembering that F is homogeneous of degree one in the two inputs, the rate of change can be written as

$$R = \frac{\frac{\partial F_C}{\partial t}\cdot C + \frac{\partial F_L}{\partial t}\cdot L}{F}. \tag{3}$$

To express R as a function of labor's relative

[3] A clear exposition of the neoclassical theory of production and distribution which is used in this paper can be found in Ferguson [7].

share, multiply the first and second terms of the numerator of (3) by F_C/F_C and F_L/F_L, respectively. Remembering that $(F_C \cdot C)/F = S_C = 1 - S_L$, and that $S_L = (F_L \cdot L)/F$, expression (3) becomes

$$R = (1 - S_L)\frac{\left(\frac{\partial F_C}{\partial t}\right)}{F_C} + S_L\frac{\left(\frac{\partial F_L}{\partial t}\right)}{F_L}. \tag{4}$$

Rate of change of labor's relative share.—It can be shown (see Appendix B) that the rate of change in the relative share of labor is given by expression (5):

$$\frac{\dot{S}_L}{S_L} = -(1 - S_L)\left[B + \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\dot{k}}{k}\right)\right] \tag{5}$$

where the dots indicate total time derivative, σ = elasticity of substitution, and k = capital-labor ratio.

Equation (5) shows that the rate of change of the relative share of labor depends on the bias (B) of technological progress, on the size of the elasticity of substitution (σ), and on the direction of change the capital-labor ratio (k). Of course, if technological progress is neutral, that is, $B=0$, then $\dot{S}_L/S_L$ depends on σ and $\dot{k}/k$. There are many ways that can result in a decline of the relative share of labor. For example, if $\sigma=1$, the relative share will decline only if technological progress is capital-using ($B>0$). The relative share of labor will also decline if $B>0$, $\sigma<1$, and $\dot{k}/k>0$; but the values of these elements are such that $B+(\sigma-1/\sigma)\ \dot{k}/k$ is positive. Expression (5) will be discussed again in terms of demand and supply of labor in the light of the statistical results.

Factor-augmenting technological progress.—Technological change of the factor-augmenting type has been introduced in a CES production function containing factor productivity variables that are functions of time [4]. Assuming constant returns to scale,[4] the factor-augmenting production function may be written as

$$Y = [[\alpha(t)C]^{-\rho} + [\beta(t)L]^{-\rho}]^{-1/\rho} \tag{8}$$

where $\alpha(t)$ and $\beta(t)$ are productivity variables of capital and labor as functions of time, and $\rho=(1-\sigma)/\sigma$. With this production function the bias of technological progress can be expressed in terms of α, β, and σ by using (8) and (2). The bias can be written as

$$B = \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\dot{\alpha}}{\alpha} - \frac{\dot{\beta}}{\beta}\right). \tag{9}$$

Substituting (9) into (5), the rate of change of the relative share of labor can be written as

$$\frac{S_L}{S_L} = -(1 - S_L) \cdot \left[\left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\dot{k}}{k} + \frac{\dot{\alpha}}{\alpha} - \frac{\beta}{\beta}\right)\right]. \tag{10}$$

From equation (10) it appears that the behavior of the relative share of labor, for a given value of σ, depends not just on the capital-labor ratio but also on the changes in the productivity of the two factors. For example, assume that $\sigma>1$. The relative share of labor will increase if the rates of change of the capital-labor ratio and of capital productivity together exceed the rate of change of labor productivity. The term $\dot{k}/k+\dot{\alpha}/\alpha-\dot{\beta}/\beta$ may be viewed as the adjusted capital-labor ratio, that is, physical units of capital and labor adjusted for their productivity [9, p. 313].

Type of factor augmentation.—The form of factor augmentation needs to be specified when statistical estimation is attempted. A common specification is to assume that factor augmentation occurs at a constant exponential rate. Thus $\alpha(t)$ and $\beta(t)$ can be written as

$$\alpha(t) = \alpha_0 e^{\lambda_C t} \text{ and } \beta(t) = \beta_0 e^{\lambda_L t}, \quad \lambda_L, \lambda_C > 0.$$

[4] This assumption is not very restrictive for our purposes. We could have assumed a homogeneous production of degree m, which is written as

$$Y = [(\alpha(t)C)^{-\rho} + (\beta(t)L)^{-\rho}]^{-\frac{m}{\rho}}.$$

The marginal product of labor of this function is

$$\frac{\partial Y}{\partial L} = Y^{1+\rho/m} m(\beta(t))^{-\rho} L^{-\rho-1}$$

and, similarly, the marginal product of capital is

$$\frac{\partial Y}{\partial C} = Y^{1+\rho/m} m(\alpha(t))^{-\rho} C^{-\rho-1}.$$

Taking the ratio of the marginal products, the parameter m cancels out. The resulting expression is given later as equation (14). It follows that the elasticity of substitution defined as

$$\sigma = \frac{d\left(\frac{C}{L}\right)}{\left(\frac{C}{L}\right)} \div \frac{d\left(\frac{\partial Y}{\partial L} \div \frac{\partial Y}{\partial C}\right)}{\frac{\partial Y}{\partial L} \div \frac{\partial Y}{\partial C}}$$

is not affected by the degree of homogeneity of the production function.

Differentiating $\alpha(t)$ and $\beta(t)$ with respect to time and dividing by α and β, we obtain

$$\frac{\dot{\alpha}}{\alpha} = \lambda_C \quad \text{and} \quad \frac{\dot{\beta}}{\beta} = \lambda_L,$$

that is, factor augmentation occurs at a constant rate for both factors of production.

In this paper we have specified $\alpha(t)$ and $\beta(t)$ as

$$(11) \quad \alpha(t) = \alpha_0 t^{\gamma_C}, \quad \beta(t) = \beta_0 t^{\gamma_L} \quad \gamma_C, \gamma_L > 0$$

This formulation implies that

$$\frac{\dot{\alpha}}{\alpha} = \gamma_C t^{-1} \quad \text{and} \quad \frac{\dot{\beta}}{\beta} = \gamma_L t^{-1},$$

that is, the rate of factor augmentation is declining. The rate of change of the relative share of labor can now be expressed as

$$(12) \quad \frac{\dot{S}_L}{S_L} = -(1 - S_L)\left(\frac{\sigma - 1}{\sigma}\right) \cdot \left[\frac{\dot{k}}{k} - (\gamma_L - \gamma_C)t^{-1}\right].$$

Since $0 < S_L < 1$ and $t > 0$, the direction of $\dot{S}_L/S_L$ depends on σ, $\dot{k}/k$, and $(\gamma_L - \gamma_C)$. Our purpose now is to obtain estimates of σ, $\dot{k}/k$, and $(\gamma_L - \gamma_C)$; and this will enable us to explain the declining relative share of labor for American agriculture.

Statistical considerations

Estimation of σ and $\gamma_L - \gamma_C$.—In order to estimate σ and $(\gamma_L - \gamma_C)$ we substitute equation (11) into (8) and obtain

$$(13) \quad Y = \left[(\alpha_0 t^{\gamma_C} C)^{-\rho} + (\beta_0 t^{\gamma_L} L)^{-\rho}\right]^{-1/\rho}.$$

By differentiating (13) with respect to C and L and taking the ratio of the resulting marginal products, we have

$$(14) \quad \frac{F_L}{F_C} = \left(\frac{\beta_0}{\alpha_0} t^{\gamma_L - \gamma_C}\right)^{-\rho}\left(\frac{C}{L}\right)^{1+\rho}.$$

Substituting[5] W/r for F_L/F_C and solving (14) for C/L, we have

$$(15) \quad \frac{C}{L} = \left(\frac{W}{r}\right)^{\sigma}\left(\frac{\beta_0}{\alpha_0} t^{\gamma_L - \gamma_C}\right)^{1-\sigma}$$

since $\sigma = 1/(1+\rho)$ and therefore $\rho/(\rho+1) = 1 - \sigma$. Taking logarithms of (15), we obtain

$$(16) \quad \log\left(\frac{C}{L}\right) = (1 - \sigma)\log\left(\frac{\beta_0}{\alpha_0}\right) + \sigma \log\left(\frac{W}{r}\right) + (\gamma_L - \gamma_C)(1 - \sigma)\log t$$

which can be estimated and supply estimates of σ and $(\gamma_L - \gamma_C)$.

From equation (16) we can estimate only the difference $(\gamma_L - \gamma_C)$, not the individual γ's. There is, however, an alternative approach that provides estimates of σ and γ_L [4, p. 367]. For equation (13) the marginal product of labor is given by

$$(17) \quad \frac{\partial Y}{\partial L} = \left(\frac{Y}{L}\right)^{1+\rho}(\beta_0 t^{\gamma_L})^{-\rho}.$$

Dividing both sides of (17) by W $(W = \partial Y/\partial L)$ and manipulating the resulting expression, we obtain

$$S_L = W^{1-\sigma}(\beta_0 t^{\gamma_L})^{\sigma-1}; \text{ and in logarithms}$$

$$(18) \quad \log S_L = (\sigma - 1)\log \beta_0 + (1 - \sigma)\log W + \gamma_L(\sigma - 1)\log t.$$

Notice that from (18) estimates of σ and γ_L can be obtained without using data on capital and interest rate.

Estimation of $\dot{k}/k$.—The rate of growth of the capital-labor ratio can be estimated directly from the available data on capital stock and labor force. Then the mean value of the estimated $\dot{k}/k$ can be used jointly with the estimates of σ and $(\gamma_L - \gamma_C)$ to explain the changes in the relative share of labor. Alternatively, one can regress $\dot{k}/k$ on time and use the predicted value of $\dot{k}/k$ for the mean year as an estimate of $\dot{k}/k$.

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[5] This substitution implies that the labor market was in equilibrium and therefore that labor is paid its marginal product. This assumption is not totally satisfactory, but it is the best we can do. The effect of deviations from this assumption on the estimate of the relative share of labor depends on the dynamics of the adjustment process when $F_L \neq W$. The specification of such process is not within the range of our intentions. Generally speaking, however, if wage rates lag behind the level of marginal product the estimated relative share of labor underestimates the true contribution of labor to total production. The opposite holds if wage rates are ahead of the level of marginal product of labor. It should be noted that we are interested in the *changes* in the relative share of labor, and therefore the consequences of the deviations from equilibrium may not disturb our results if the direction and amount of $W - F_L$ remain approximately the same throughout the period we are covering.

Empirical results

Data.—To estimate equations (16) and (18) we need data on total agricultural output (Y), capital services (C), labor employment (L), return to capital (r), and wage rate (W). Estimates of Y, L, and W for the 1949–1968 period are available in the sources referred to earlier. From these data we were able to compute the relative share of labor as shown earlier. The measure of capital used here is based on data reported in [20]. Capital consists of the following items: feed, livestock, seed, fertilizer, repairs and operation of capital items, depreciation and other consumption of farm capital, and interest on farm mortgage debt. The resulting series was deflated by the index of prices paid by farmers (1957–59 = 100). As interest rate we used the Production Credit Association's average cost of loans, which is also reported in [20]. The limited reliability of this cost as an estimate of the return to capital is one reason for using equation (18) to obtain an estimate of the elasticity of substitution. The rate of interest was also deflated by the index of prices paid by farmers.

Estimates of σ, $\gamma_L - \gamma_C$, and γ_L.—For statistical estimation of (16) and (18) an error term needs to be added. Thus we rewrite (16) as

$$\text{(16a)} \quad \log\left(\frac{C}{L}\right)_t = a_0 + a_1 \log\left(\frac{W}{r}\right)_t + a_2 \log t + U_t$$

where

$$a_0 = (1 - \sigma)\log\left(\frac{\beta_0}{\alpha_0}\right),$$

$$a_1 = \sigma,$$

$$a_2 = (\gamma_L - \gamma_C)(1 - \sigma), \quad \text{and}$$

$$U_t \sim NID(0, \sigma_U^2).$$

The assumed distribution of U_t implies that we have multiplied equation (15) by e^u which has a lognormal distribution. Equation (18) can be written as

$$\text{(18a)} \quad \log S_{Lt} = b_0 + b_1 \log W_t + b_2 \log t + V_t$$

where

$$b_0 = (\sigma - 1) \log \beta_0,$$

$$b_1 = 1 - \sigma,$$

$$b_2 = \gamma_L(\sigma - 1), \quad \text{and}$$

$$V_t \sim NID(0, \sigma_V^2).$$

Application of direct least squares to equation (16a) resulted in the following regression equation:

$$\text{(16b)} \quad \log\left(\frac{C}{L}\right) = \underset{(4.92)}{3.011} + \underset{(5.72)}{1.524} \log\left(\frac{W}{r}\right) + \underset{(3.83)}{.197} \log t.$$

$$\text{d.f.} = 17 \quad \bar{R}^2 = .95 \quad \text{D-W} = 1.03$$

The t values are reported in the parentheses. From regression (16b) we obtain

$$\hat{\sigma} = 1.524$$

$$(\widehat{\gamma_L - \gamma_C}) = \frac{a_2}{1 - \hat{\sigma}} = -.375$$

$$\hat{S}_\sigma = .26$$

$$\hat{S}_{(\widehat{\gamma_L - \gamma_C})} = .28^{6}$$

Application of direct least squares to equation (18a) gives the following regression:

$$\text{(18b)} \quad \log S_L = \underset{(-8.16)}{-1.09} - \underset{(-4.07)}{1.44} \log W - \underset{(-2.56)}{1.32} \log t.$$

$$\text{d.f.} = 17 \quad \bar{R}^2 = .91 \quad \text{D-W} = .42$$

Estimates of σ and γ_L derived from regression (18b) are

$$\hat{\sigma} = 2.44 \qquad \hat{S}\hat{\sigma} = .35$$

$$\hat{\gamma}_L = -.916 \qquad \hat{S}\hat{\gamma}_L = .25$$

Our interest is not in the regression coefficients but in the structural parameters σ and $(\gamma_L - \gamma_C)$. From equation (16b) we obtain an

[6] The variance of $(\widehat{\gamma_L - \gamma_C})$ has been estimated by a Taylor's expansion using only the first order terms. Since $(\widehat{\gamma_L - \gamma_C}) = a_2/(1 - \hat{a}_1)$, the variance of $(\widehat{\gamma_L - \gamma_C})$ is

$$V(\widehat{\gamma_L - \gamma_C}) = \left(\frac{1}{1 - \hat{a}_1}\right)^2 V(\hat{a}_2) + \left[\frac{\hat{a}_2}{(1 - \hat{a}_1)^2}\right]^2 V(\hat{a}_1) + 2\left(\frac{1}{1 - \hat{a}_1}\right)\left[\frac{\hat{a}_2}{(1 - \hat{a})^2}\right] \text{Cov}\ (\hat{a}_1, \hat{a}_2).$$

A similar formula has been used for the estimation of variance of other ratios.

elasticity of substitution greater than one and an estimate of $(\gamma_L - \gamma_C)$ that indicates that the productivity of capital in the agricultural sector has increased faster than the productivity of labor. From equation (18b) we obtain an elasticity of substitution greater than two and an estimate of γ_L that is less than zero. Since for the model the value of γ_L has been restricted to positive numbers (see equation (11)), this result is inadmissible. Regression (18b) also suffers from autocorrelation as indicated by the value of the Durbin-Watson statistic. The explanatory power of (16b) is also greater, as the adjusted $\bar{R}^2$ is greater than that of regression (18b). Equation (16b) is therefore preferable to (18b), and the results of (18b) will not be used further. However, an attempt to correct regression (18b) for autocorrelation was made and the results are reported in the next section.

Considering equation (16b), the estimate of σ is directly obtained from the regression coefficient, and its significance can be tested using a t-distribution. The estimated σ is significant at .01 level of significance. The estimate of $(\gamma_L - \gamma_C)$ is obtained indirectly as the ratio of two coefficients. A test of significance for $(\gamma_L - \gamma_C)$ presents a difficulty as the two coefficients forming the ratio, i.e., $a_2/(1-a_1)$, are both normally distributed with nonzero means and different variances. The difficulty is that the distribution of the ratio of two normal variables with nonzero means is unknown.[7] Since the estimate of $(\gamma_L - \gamma_C)$ is greater in absolute value than its standard error $(|1-.3751| > .28)$, we accept it as significant.

Additional estimates of σ, $(\gamma_L - \gamma_C)$, and γ_L.—Additional estimates of σ and $(\gamma_L - \gamma_C)$ were obtained by introducing a Nerlove-type adjustment process in the capital-labor ratio. Since the model is written in logarithms, the adjustment process is expressed as

$$\log\left(\frac{C}{L}\right)_t - \log\left(\frac{C}{L}\right)_{t-1} = \lambda\left[\log\left(\frac{C}{L}\right)_t^* - \log\left(\frac{C}{L}\right)_{t-1}\right] \tag{19}$$

where $(C/L)_t^*$ is the desired capital-labor ratio in period t. Under this formulation the left-hand term of equation (16a) is the desired capital-labor ratio; therefore, by combining (16a) and (19) we obtain the well-known result in equation (20):

$$\log\left(\frac{C}{L}\right)_t = c_0 + c_1 \log\left(\frac{C}{L}\right)_{t-1} + c_2 \log\left(\frac{W}{r}\right)_t + c_3 \log t + U_t \tag{20}$$

where

$$c_0 = \lambda(1-\sigma)\log\left(\frac{\beta_0}{\alpha_0}\right),$$

$$c_1 = 1 - \lambda,$$

$$c_2 = \lambda\sigma,$$

and

$$c_3 = \lambda(\gamma_L - \gamma_C)(1-\sigma).$$

Equation (20) was estimated by a two-stage least squares procedure [12, p. 41] by substituting $\log\ (\hat{C}/L)_{t-1}$ for $\log\ (C/L)_{t-1}$, where $(\hat{C}/L)_{t-1}$ is the predicted value of $(C/L)_{t-1}$ based on the other independent variables. The resulting regression is

$$\log\left(\frac{C}{L}\right)_t = \underset{(2.62)}{2.08} + \underset{(.72)}{.225} \log\left(\frac{C}{L}\right)_{t-1} + \underset{(2.76)}{1.09} \log\left(\frac{W}{r}\right) + \underset{(1.49)}{.193} \log t. \tag{21}$$

$$\text{d.f.} = 15 \qquad \bar{R}^2 = .95$$

From regression (21) we have

$$\hat{\lambda} = .775 \qquad \hat{S}_{\hat{\lambda}} = .72$$

$$\hat{\sigma} = 1.277 \qquad \hat{S}_{\hat{\sigma}} = .42$$

$$\widehat{(\gamma_L - \gamma_C)} = -.88 \qquad \hat{S}_{\widehat{(\gamma_L-\gamma_C)}} = .58$$

These results confirm that the productivity of capital has increased more than the productivity of labor. In terms of a typical statistical test, the hypothesis that σ is equal to unity is accepted at .05 significance level. It may be noted, however, that the estimated value of σ and its standard error give a probability of about 74 percent that σ is greater than unity, using the normal approximation.

[7] If the means of the two variables were zero, the ratio would follow a Cauchy-distribution that has no moments, and thus testing would be impossible.

In an attempt to obtain better estimates of σ and particularly of γ_L from equation (18a), the following iterative procedure suggested by Johnston [13, p. 194] was used.

Step 1. Regress the independent variable $\log S_L$ on the dependent variables $\log W$ and $\log t$ and obtain estimates of the parameters denoted b_0^1, b_1^1, and b_2^1.

Step 2. From the regression in step 1 obtain estimates of the error term V_t^1, and regress V_t^1 on V^1_{t-1} to obtain an estimate of the correlation coefficient ρ denoted ρ_1.

Step 3. Using ρ_1 compute the transformed variables $(\log S_{L,t}-\rho_1 \log S_{L,t-1})$, $(\log W_t - \rho_1 \log W_{t-1})$ and $(\log t-\rho_1 \log t-1)$.

Step 4. Regress $(\log S_{L,t}-\rho_1 \log S_{L,t-1})$, $(\log W_t-\rho_1 \log W_{t-1})$, and $(\log t-\rho_1 \log (t-1))$ to obtain new estimates of the parameters denoted by b_0^2, b_1^2, and b_2^2.

Step 5. Repeat step 2 with the regression results of step 4 and continue the iterations until the residuals are not significantly autocorrelated.

This procedure assumes that the error term of equation (18a) has the following autoregressive structure:

$$V_t = \rho V_{t-1} + Z_t \quad \text{where} \quad Z \sim NID(0, \sigma^2_Z)$$

After two iterations this procedure has given the following results:

$$\begin{array}{lll} b_0 = -.0035 & (t=-.083) & \bar{R}^2 = .77 \\ b_1 = -.6020 & (t=-2.010) & \text{d.f.} = 17 \\ b_2 = -.5030 & (t=-7.210) & \text{D-W} = .92 \\ \rho = .5400 & (t=2.590) & \end{array}$$

From these estimates we have

$$\hat{\sigma} = 1.602 \qquad \hat{S}_{\hat{\sigma}} = .30$$
$$\hat{\gamma}_L = -.835 \qquad \hat{S}_{\hat{\gamma}_L} = .46$$

Notice that the estimate of the elasticity of substitution is now consistent with the other two estimates obtained from equations (16a) and (18a). It is also statistically greater than unity. The estimate of γ_L retains its negative sign, but now it is insignificant at the .05 level of significance. Although the estimate of γ_L is unsatisfactory, these results suggest that the elasticity of substitution is most likely greater than one.[8,9]

Estimates of $\dot{k}/k$ and $\dot{S}_L/S_L$—Two estimates were obtained for each rate of growth. The first estimate is simply the mean value of all observations; that is, the estimate is based on the observable quantities of capital and labor for $\dot{k}/k$, and employment, wage rate, and total product for $\dot{S}_L/S_L$. The estimates are

$$\text{(a)} \quad \begin{array}{ll} \dfrac{\dot{k}}{k} = .0626 & \text{standard error of } \dfrac{\dot{k}}{k} = .019 \\ \dfrac{\dot{S}_L}{S_L} = -.0428 & \text{standard error of } \dfrac{\dot{S}_L}{S_L} = .0264 \end{array}$$

The second estimate was obtained by regressing each rate of growth on t and t^2 (t=time) and estimating the theoretical value of the rate of growth for the mid-value of t. Thus we received

$$\text{(b)} \quad \begin{array}{ll} \dfrac{\dot{k}}{k} = .06703 & \text{standard error of } \dfrac{\dot{k}}{k} = .067 \\ \dfrac{\dot{S}_L}{S_L} = -.053 & \text{standard error of } \dfrac{\dot{S}_L}{S_L} = .047 \end{array}$$

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8 Quirino Paris has suggested that an independent estimate of the elasticity of substitution can be obtained by using the following expression provided by Allen [1, p. 373]:

$$(1') \qquad e_L = -[(1 - S_L)\sigma + S_L e_Y]$$

where e_L=price elasticity of demand for labor, S_L=relative share of labor, σ=elasticity of substitution, and e_Y=price elasticity of demand for output defined as $e_Y = -(P/Y)\cdot(dY/dP)$.

Estimates of e_L are available in Wallace and Hoover [22] and Bauer [2]. The estimates are respectively -1.433 and -1.482. The price elasticity of demand for agricultural commodities may be assumed to be approximately $-.5$. For example, Brandow [3] has found the elasticity of demand for nuts and fruits to be $-.35$, and George [11] has estimated the elasticity of demand for fresh fruits and canned fruits and vegetables to be equal to $-.6$ and $-.4$ respectively. The average relative share of labor has been estimated in this paper to be equal to .294. Thus $1-S_L=.706$ Using $e_L=-1.482$ and $e_Y=.35$, the elasticity of substitution is estimated from equation (1′) above to be equal to 1.95. Using $e_L=-1.433$ and $e_Y=.5$ the elasticity of substitution is 1.82; and for $e_Y=1.0$, $\hat{\sigma}=1.61$.

If one uses Ruttan and Stout's [18] mean estimates for the relative share of labor for the period 1947–1957, where $S_L=.267$, with $e_L=-1.433$ and $e_Y=.5$, the elasticity of substitution becomes 1.77.

In view of the result obtained from equation (21) where, formally speaking, the elasticity of substitution was found to be no different from unity, these additional results are helpful and clearly support the findings that $\sigma>1$. It seems clear to us that the elasticity of substitution is greater than unity.

9 An additional source of confidence in the estimates of the elasticity of substitution is the work done by Kaneda [14]. He has found $\hat{\sigma}=1.1368$ with S.E. = .0236 and thus $\hat{\sigma}$ is greater than unity. Our estimates tend to be higher, but the difference may be explained by the longer time-period data available to us. In the context of this study Kaneda's footnote 4 [14, p. 205] is particularly relevant.

It appears that the estimates of $\dot{k}/k$ are close together, but the estimate in (a) is preferable because of its small standard error. The estimates of $\dot{S}_L/S_L$ differ substantially; and again using the reliability of the estimate as a criterion, we choose estimate (a) as preferable. Thus in the subsequent analysis we use $\dot{k}/k = .0626$ and $\dot{S}_L/S_L = -.0428$ as estimates of the two rates of growth. For completeness, we also use the other two values of $\dot{S}_L/S_L$ presented in Table 1 in combination with the same value of $\dot{k}/k$.

Sources of decline in the relative share of labor

Equipped with the information obtained from the estimation of the basic equation (16), we can now look for the sources of decline in the relative share of labor in American agriculture from an empirical point of view. For convenience we reproduce the basic relationship expressed in equation (12):

$$\frac{\dot{S}_L}{S_L} = -(1 - S_L)\left(\frac{\sigma - 1}{\sigma}\right) \cdot \left[\frac{\dot{k}}{k} - (\gamma_L - \gamma_C)t^{-1}\right]. \tag{12}$$

Now we estimate $\dot{S}_L/S_L$ from equation (12) based on the estimates of σ, $(\gamma_L - \gamma_C)$, $\dot{k}/k$, and the three estimates of the mean of the relative share of labor presented in Table 1. Three estimates of $\dot{S}_L/S_L$ were obtained, based on

$$S_L = .294 \qquad S_L' = .501$$

and

$$S_L'' = .282$$

each combined with

$$\hat{\sigma} = 1.524, \qquad (\widehat{\gamma_L - \gamma_C}) = -.375$$

and

$$\frac{\dot{k}}{k} = .0626.$$

The obtained estimates are

(i) $\dot{S}_L/S_L = -.0243,$ based on $S_L = .294$

(ii) $\dot{S}_L/S_L = -.0172,$ based on $S_L' = .501,$

and

(iii) $\dot{S}_L/S_L = -.0247,$ based on $S_L'' = .282.$

Observe now that the three estimates of $\dot{S}_L/S_L$ just obtained fall within the corresponding 5 percent confidence limits that can be constructed from the direct estimates of $\dot{S}_L/S_L$ presented in Table 1. This increases our degree of confidence in the estimates of σ and $(\gamma_L - \gamma_C)$. Of course, the various estimates differ from each other. The important point, however, is that the elasticity of substitution is greater than unity, and the difference of the productivity parameters is consistently negative. Let us now combine these two findings.

Technological progress in American agriculture has been capital-using. This can be seen by means of equation (9). From the results of equation (16a), for example, we have:

$$B = \frac{\sigma - 1}{\sigma}(\gamma_C - \gamma_L)t^{-1} = (.344)(.0375)$$
$$= .129 > 0.$$

According to the definition of bias used here, this means that technological progress has increased the marginal product of capital relative to that of labor. Given a factor-price ratio, this would give an incentive to producers to substitute capital for labor, that is, to increase the capital-labor ratio. In fact, the capital-labor ratio in physical units has gone up. Also, the adjusted capital-labor ratio, the expression in the brackets in equation (12), has gone up. As it is shown in equation (12), the change in the relative share of labor depends not only on the changes in the capital-labor ratio but also on the elasticity of substitution which has been found to be greater than unity. These two factors combined result in a decline in the relative share of labor, as it can be seen from equation (12).

Within the framework of the agricultural labor market, the decline in the relative share of labor can be explained as follows. Given the volume of total output, the factor-price ratio, and the easiness of capital-labor substitution ($\sigma > 1$), capital-using technological progress will reduce the demand for labor. With no changes in the supply of labor, the result would be a decline in wages and employment and therefore a decline in the relative share of labor and a corresponding increase in the relative share of capital. Of course, the volume of total output has increased in the period covered in this study, and the supply schedule of labor was

shifted to the left with the continuing movement of labor from the agricultural to the nonagricultural sector. These two changes (increased output and rural-urban migration) have been strong enough to increase the wage rate in the agricultural labor market, but the increase in output has not been strong enough to outweigh the effect of labor-saving technological progress and to prevent a decline in farm employment. The data show that the wage bill (W·L) has decreased and output has increased. Thus the relative share of labor (WL/Y) has declined.

Elasticity of substitution, technological progress, and labor's relative share in the farm and nonfarm sectors: a comparison

It is interesting to compare our results for agriculture with some similar results obtained for the nonagricultural sector for approximately the same period of time. Ferguson [7] and McKinnon [17] have found that for most industries the elasticity of substitution is less than unity. Ferguson and Moroney [9] have found that it is substantially less than unity. In our study the elasticity of substitution is found to be substantially greater than unity.

The bias of technological progress varies from industry to industry. Ferguson and Ferguson and Moroney in the same studies have found that both capital-using and labor-using technological changes have occurred in the postwar period. However, it appears that a capital-using technology is introduced more often than a labor-using one. In agriculture technological progress has been capital-using.

In all industries except three (one, tobacco, with a decline and two with no change) the relative share of labor has increased [9]. The average rate of increase for all industries is approximately .009. In agriculture the relative share of labor has decreased with an average rate of −.0391.

It is not within the scope of this study to compare the increasing share of labor in manufacturing with the decreasing share of labor in agriculture. We suggest, however, that the difference in the direction of changes may be partly explained by the differential rate of growth of output in the two sectors and the different degree of labor mobility in the two labor markets, given of course the differences in the nature of production that leads to different elasticities of substitution and the rate of technological advancement.

Summary and Concluding Remarks

In the postwar period the relative share of labor in U. S. agriculture has decreased approximately 50 percent, from 42.71 percent in 1949 to 19.99 percent in 1968. This decline is in contrast to the postwar development in manufacturing where the relative share of labor has increased.

Within the framework of neoclassical theory of production and distribution we have attempted to explain the decline in labor's relative share by estimating the elasticity of substitution, the changes in the capital-labor ratio, and the difference in the factor productivity indices. The estimation is based on a constant elasticity of substitution production function which assumes factor-augmenting technological change and constant returns to scale. The rate of factor augmentation is assumed to be declining. The derived statistical models provide us with estimates of the bias of technological change, the elasticity of substitution, and the difference of the factor-augmentation parameters.

The obtained estimates show that (1) according to Hicks' definition of neutrality of technological progress, American agriculture is characterized by capital-using technological progress; (2) the elasticity of substitution is greater than unity; and (3) productivity of capital in agriculture increases faster than productivity of labor. The capital-labor ratio is increasing, and when adjusted for factor-productivity changes it increases even faster.

This analysis refers to the demand side of the labor market and it suggests that the demand for labor is declining. For the explanation of the declining share of labor, the supply side of the labor market needs to be considered. It is well-known that supply of labor in agriculture is also declining, primarily as a response to the relatively increasing economic opportunities in the urban areas. These changes suggest that the product $W \cdot L$, which is the wage bill and the numerator of the definitional formula of relative share of labor ($S_L = WL/Y$), may increase, decrease, or remain constant. Actually it has decreased from approximately $12.8 billion in 1949 to $8.3 billion in 1968. Therefore, although output has increased only moderately, the relative share of labor has decreased substantially.

In view of the fact that Cobb-Douglas production functions (with elasticity of substitu-

tion equal to one) have been traditionally used in agriculture, our finding that the elasticity of substitution appears to be greater than unity has special significance for further research. We suggest that the assumption of unitary elasticity of substitution may not be appropriate, and we may have to sacrifice the simplicity of the Cobb-Douglas production function and adopt a CES production function. Also, our finding that the productivity of capital has increased more than the productivity of labor should make the reader cautious as to the meaning of productivity indices, such as productivity per man-hour.

The reader would have noticed that we have not discussed the causes of factor-augmentation This is a topic in the area of investigations of the sources of productivity growth and falls outside the scope of this study. As far as labor is concerned, however, one may mention the increasing volume of current research that attributes increases in labor productivity to the improving quality of labor input due primarily to the educational attainments of the labor force.

Admittedly, this study is just a first cut into a complex problem with important social consequences. An obvious next step is to examine the changes in the relative share of labor at the regional level. Any observed differences among regions would then raise the question of the effect of regional differences in the rate of industrial development on the agricultural labor market, and useful policy suggestions may be derived. Further, our study lends support to the thesis that outmigration from agriculture has not been fast enough, and thus it suggests that more attention should be given to the supply of labor side of the market with emphasis on the causes of labor immobility.

Appendix A. Basic time series used in the study

Year	$W\cdot L$ (million constant dollars)	W/r	C/L	$\dot{k}/k$	S_L	$\Delta S_L/S_L$	S_L'	$\Delta S_L'/S_L'$	S_L''	$\Delta S_L''/S_L''$
1949	12,816	0.1140	0.8246	0.0232	0.4271		.7223		.365	
1950	11,867	0.1148	0.9547	0.1362	0.4052	−.0519	.6787	−.0603	.333	−.0876
1951	12,076	0.1266	1.0325	0.0753	0.4153	.0249	.7337	.0810	.322	−.0330
1952	11,929	0.1279	1.0756	0.0400	0.3979	−.0418	.7036	−.0410	.321	−.0031
1953	11,970	0.1291	1.0780	0.0022	0.3880	−.0248	.6652	−.0545	.351	.1059
1954	11,353	0.1273	1.1860	0.0910	0.3606	−.0706	.6131	−.0783	.336	−.0427
1955	11,169	0.1385	1.2447	0.0471	0.3416	−.0526	.5783	−.0567	.334	−.0059
1956	10,885	0.1387	1.3340	0.0669	0.3279	−.0401	.5451	−.0574	.327	−.0209
1957	9,931	0.1321	1.4725	0.0940	0.3027	−.0768	.5147	−.0557	.306	−.0642
1958	9,704	0.1369	1.6507	0.1079	0.2820	−.0683	.4754	−.0763	.271	−.0816
1959	9,590	0.1461	1.7217	0.0412	0.2718	−.0361	.4601	−.0321	.280	.0332
1960	9,315	0 1337	1.8106	0.0490	0.2579	−.0511	.4361	−.0521	.266	−.0500
1961	9,033	0.1497	1.9116	0.0528	0.2442	−.0531	.4102	−.0593	.254	−.0451
1962	8,638	0.1588	2.0894	0.0850	0.2294	−.0606	.3909	−.0470	.238	−.0672
1963	8,499	0.1666	2.2036	0.0518	0.2177	−.0510	.3712	−.0754	.233	−.0210
1964	8,202	0.1669	2.2810	0.0339	0.2152	−.0114	.3733	.0056	.237	.0171
1965	8,055	0.1729	2.4770	0.0791	0.1996	−.0724	.3441	−.0782	.215	−.0928
1966	7,964	0.1790	2.7480	0.0986	0.1989	−.0781	.3420	−.0061	.206	−.0418
1967	8,330	0.1824	2.9120	0.0563	0.1970	−.0095	.3323	−.0283	.219	.0631
1968	8,328	0.1961	2.9700	0.0195	0.1999	.0101	.3337	.0042	.224	.0228

Appendix B

We want to show that

$$(5)\quad \frac{\dot{S}_L}{S_L} = -(1-S_L)\left[B + \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\dot{k}}{k}\right)\right].$$

It is shown [8, pp. 224–227] that the rate of the marginal product of labor can be written as

$$(6a)\quad \frac{\dot{F}_L}{F_L} = R - (1-S_L)B + \frac{(1-S_L)}{\sigma}\left(\frac{\dot{k}}{k}\right)$$

and the rate of growth of output can be written as

$$(6b)\quad \frac{\dot{F}}{F} = R + (1-S_L)\frac{\dot{k}}{k} + \frac{\dot{L}}{L}.$$

From the definition of the relative share of labor, i.e., $S_L = WL/Y$, by taking total time derivative of S and dividing both sides by S we obtain

$$(7)\quad \frac{\dot{S}_L}{S_L} = \frac{\dot{W}}{W} + \frac{\dot{L}}{L} - \frac{\dot{Y}}{Y}.$$

Remembering the assumption that $W = F_L$ and substituting (6a) and (6b) into equation (7), equation (5) is obtained.

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Tariffs, Nontariff Distortions, and Effective Protection in U. S. Agriculture*

LARRY J. WIPF

This paper extends the effective-protection concept to include tariff and nontariff trade distortions and also the entire structure of domestic farm policy measures. Nominal and effective rates of protection are then presented for disaggregated agricultural production and processing industries for the years 1958, 1963, and 1968. The estimates reveal that nontariff measures give rise to extremely high effective protection rates in certain agricultural sectors; in others, tariff and nontariff measures affecting intermediate inputs have important taxation effects. The analysis also indicates that agricultural policy changes have substantially altered the rates of protection accorded certain agricultural sectors.

IN RECENT YEARS the concept of effective tariff protection has received considerable attention by international trade specialists. This concept of protection is concerned with the production side of the economy and arises from the fact that the existence of intermediate goods complicates the effects upon industry levels of operations of the structure of nominal rates. In particular, recent contributions have recognized that

> . . . a tariff on a good used in a productive process is equivalent to a tax on the output of that process, and the consequent necessity of distinguishing sharply between the structure of tariff rates on commodities entering international trade (*nominal rates*), and the structure of rates of protection accorded by the tariff structure to the specific processes or stages of production that make up the productive system (*effective rates*) [4, p. 10].[1]

The effective-rate-of-protection concept has moved rapidly from theory to measurement of effective tariff levels for the manufacturing sectors of various countries.[2] On the other hand, presumably because of the complexities of agricultural policies and the resulting stringent data requirements, the agricultural sectors have usually been omitted from the analysis. Nevertheless, the application of the effective-protection concept need not be limited to the analysis of tariff protection. In this paper it is extended to include (1) other trade-distorting measures such as quantitative restrictions, variable levies, and export subsidies; and (2) indirect taxes, domestic price support provisions, and subsidies—such as direct income payments and cost-lowering production aids—which directly affect only domestic producers. Nominal and effective protection estimates are then presented for disaggregated U. S. agricultural production and processing sectors involving the years 1958, 1963, and 1968. In addition, variations in these rates of protection are related to agricultural policy changes over the period 1958–1968.

The Effective Protection Model

We begin by considering the effective-protection concept. The effective rate of protection afforded a particular domestic industry depends not only on the tariff and nontariff policies affecting its final output but in addition is a function of the input coefficients of this sector and the tariff and nontariff distortions affecting the inputs used by this industry. More explicitly, the effective rate of protection of industry j (g_j) is defined as the percentage difference between the industry's value added per dollar of output under protection (v_j') and its value added per dollar of output in the absence of tariff and nontariff distortions (v_j), as shown in the following equation:

$$g_j = \frac{v_j' - v_j}{v_j} \tag{1}$$

In this model we make the following assumptions:

1. All production functions are of a fixed coefficient form with zero elasticity of substitution between intermediate inputs and primary factors.

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[1] Italics mine.

[2] For a partial survey of the literature see Balassa [1], Basevi [2], Corden [3], and Johnson [4].

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2. All goods are traded before and after the introduction of protection.

3. Supplies of imports are infinitely elastic.

4. The elasticity of demand for all exports is infinite.

5. Primary factors are mobile nationally but immobile internationally, fixed in terms of total supply for the economy, and available in less than infinitely elastic supply for a particular industry.

Under these assumptions and given input-output data valued at world market prices, free trade and protected value added (per dollar of output) can be written as

$$(2) \quad v_j = 1 - \sum_i a_{ij}$$

$$(3) \quad v_j' = 1 + T_j + s_j - \sum_i a_{ij}(1 + T_i)(1 + e_i)$$

where

a_{ij} = the value of the ith input required per dollar value of output of industry j, at free trade prices;

T_j = total nominal rate for tariff and nontariff measures (except direct subsidy payments) on final output of industry j;

s_j = direct subsidy payment rate received by domestic producers in industry j;

T_i = total nominal rate for tariff and nontariff measures (except indirect taxes) on input i;

e_i = excise tax rate on intermediate input i.

Now substituting equations (2) and (3) into (1), we obtain the following expression for the effective rate of protection:

$$(4) \quad g_j = \frac{T_j + s_j - \sum_i a_{ij}(T_i + e_i + T_i e_i)}{1 - \sum_i a_{ij}}$$

Note that tariffs, import quotas, and price-distorting domestic policies may either subsidize or tax domestic production, depending on whether they apply to an output or an input. In contrast, domestic output subsidies increase protection directly in the industries receiving subsidy payments but do not tax industries that use these commodities as inputs, since the market prices of these goods are not affected by subsidy payments. It should also be mentioned that owing to the existence of border tax adjustments, which impose excise taxes on imports and rebate these taxes on exports, domestic and foreign products carry the same excise tax burden. Thus, a selective indirect tax, such as an excise tax, does not affect effective-protection rates in industries producing the goods on which these taxes are levied. However, the effective rate of protection decreases in those industries that use the taxed products as inputs but are not permitted to receive a rebate for indirect taxes paid on inputs. This being the case, the intermediate input coefficients are also adjusted for the price-raising effects of indirect taxes.

The effective rate formula shown in equation (4) can be rewritten as

$$(5) \quad g_j = (T_j + s_j) + \frac{(T_j + s_j - \bar{d}_i) \sum_i a_{ij}}{1 - \sum_i a_{ij}}$$

where

$$\bar{d}_i = \frac{\sum_i a_{ij}(T_i + e_i + T_i e_i)}{\sum_i a_{ij}}$$

is a weighted average of the tariff and nontariff measures that act to raise the cost of inputs entering the production process of industry j. This last equation makes it easy to identify the critical points in the relationship between nominal and effective rates of protection. In particular, note that

$$g_j > T_j + s_j \qquad \text{when } T_j + s_j > \bar{d}_i$$
$$g_j < T_j + s_j \qquad \text{when } T_j + s_j < \bar{d}_i$$
$$g_j = T_j + s_j \qquad \text{when } T_j + s_j = \bar{d}_i$$

Also note that the effective rate of protection can be negative, implying a tax on domestic production. This occurs when the numerator of equation (4) is less than zero (i.e., when the protective measures on final output are less than the weighted sum of tariff, quota, and domestic price-distorting policies on intermediate inputs). Negative effective rates may exist for import-competing industries and are extremely likely for exportable goods that receive no export assistance. The following analysis reveals the distorted view of protection that can be obtained by looking at selected tariff and nontariff measures in isolation and points out the need to consider the net effects of tariff and nontariff measures upon industry levels of operation.

Up to this point the various effective-protec-

tion formulae have been developed by starting from a free-trade situation and then introducing trade-distorting measures. While this approach is convenient for exposition, the resulting formulae are not suited for empirical application since we do not observe free-trade input-output values. Now, considering an input-output system expressed in terms of actual transaction flows valued at domestic prices, the effective-rate-of-protection formula can be reformulated as:

$$g_j = \frac{\dfrac{X_j'}{(1+e_j)} - \sum_i M_{ij}'}{\dfrac{X_j'}{(1+T_j)(1+e_j)} - \sum_i \dfrac{M_{ij}'}{(1+T_i)(1+e_i)}} - 1 \tag{6}$$

where X_j' is the total domestic value of industry j's output at consumers' prices and M_{ij}' is the total domestic value of the intermediate input i used in the production of j. Equation (6) represents the general type of formula used to compute the various effective protection rates presented in the next section.

Empirical Results

Estimates of nominal and effective rates of protection are reported for two stages of U. S. agricultural production: the farm level and the processed-product level. In the case of effective protection rates, calculations were made for total protection (i.e., combination of tariff and nontariff measures) and for the separate effects of tariff and nontariff distortions. The computations are based on U. S. input-output data for 1958 and information pertaining to trade distortions affecting either intermediate inputs or final output of a given industry in 1958, 1963, and 1968.[3] The distortions considered include import duties, import quotas and controls, the price-increasing provisions of domestic farm programs (together with the import quotas and export subsidies that accompany these measures), direct subsidy or support payments, American selling price valuation practices, federal subsidization of highway transportation, and indirect taxes.

Table 1 presents rates of protection for 17 farm-level sectors, 11 processing industries, and 3 composite groups formed by these sectors for the years 1958 and 1963.[4] Columns (1) and (2) show the total nominal and total effective rates for 1958; effective tariff and effective nontariff rates are listed in columns (3) and (4); and the corresponding rates for 1963 are shown in columns (5) to (8).

First we shall consider the 1958 rates of protection. The difference between the total nominal and total effective rates is considerable. The range of the total effective rates is approximately four times the range of the corresponding nominal rates. Total nominal rates ranged from zero percent for forest products to about 62 percent for sugar processing, while the total effective rates ranged from a minus 28 percent for poultry and eggs to approximately 228 percent for sugar crops. Even more important is the fact that the degree of escalation in the effective rates varies greatly for the individual agricultural sectors. We find that the total effective rates for food grains and sugar crops are almost four times as large as their total nominal rates. In contrast, the total effective rates for sectors such as meat animals and oil-bearing crops differ little from their nominal rates, indicating that the protective measures for final output are approximately offset by cost-increasing measures affecting intermediate inputs used by these sectors. Also note that negative effective rates occur in 6 of the 28 disaggregated agricultural sectors, signifying that instead of being

[3] Because 1958 input–output data were used for all effective rate calculations, the rates for 1963 (1968) should be interpreted as measuring the effective protection levels that would have occurred in 1958 given the adoption of the policies existing in 1963 (1968). These rates would be equal to the actual effective protection levels in 1963 (1968) if the input–output structures were truly identical in 1958 and 1963 (1968). A more detailed discussion of data sources and computational procedures is contained in the appendix to this paper as well as in my dissertation [11].

[4] The three industry groups—livestock and livestock products, other agricultural products, food and kindred products—are identified as sectors 1, 2, and 14, respectively, in the 1958 input–output study [10]. The 17 farm-level sectors correspond to a disaggregation of sectors 1 and 2, while the nine food processing sectors are a disaggregation of industry 14. The two remaining processing sectors—tobacco manufacturers and fabrics, yarn, and thread mills—correspond to sectors 15 and 16 in the 1958 input–output table.

Table 1. Nominal and effective protection in U. S. agriculture: 1958 and 1963[a]

Input-output sector	1958 protection rates				1963 protection rates			
	TOT NOM (1)	TOT EFF (2)	EFF TRF (3)	EFF NT (4)	TOT NOM (5)	TOT EFF (6)	EFF TRF (7)	EFF NT (8)
				percent				
Farm-level sectors								
Meat animals	8.6	10.8	14.5	− 3.7	9.2	14.6	14.7	− 0.1
Poultry and eggs	0.5	−28.0	− 5.2	−22.8	0.3	−11.7	− 6.4	− 5.3
Farm dairy products	17.6	41.3	− 5.8	47.1	13.6	31.9	− 9.8	41.7
Other livestock products	0.7	− 4.8	− 1.9	− 2.9	0.2	− 5.4	− 5.2	− 0.2
Food grains	40.3	144.4	− 2.7	147.1	41.3	158.5	− 2.8	161.3
Feed crops	13.2	22.6	3.4	19.2	3.7	8.8	7.4	1.4
Cotton	19.8	57.1	− 1.2	58.3	32.2	95.0	− 1.3	96.3
Tobacco	11.7	19.0	20.5	− 1.5	15.0	24.4	15.2	9.2
Oil-bearing crops	7.2	9.2	13.6	− 4.4	10.3	13.6	− 0.5	14.1
Vegetables	16.6	25.5	26.6	− 1.1	16.4	24.8	27.7	− 2.9
Fruits	15.2	19.8	21.8	− 2.0	14.1	17.5	20.2	− 2.7
Tree nuts	23.0	32.9	40.1	− 7.2	13.2	12.4	22.1	− 9.7
Legume and grass seeds	4.5	5.1	7.1	− 2.0	4.7	4.9	7.5	− 2.5
Sugar and sirup crops	57.4	227.7	34.1	193.6	−6.3	72.6	17.5	55.1
Miscellaneous crops	5.2	12.1	13.5	− 1.4	8.3	19.7	21.9	− 2.2
Forest products	0.0	− 0.7	− 0.1	− 0.6	0.0	− 0.9	− 0.1	− 0.8
Greenhouse products	5.2	5.1	6.0	− 0.9	4.8	4.5	5.7	− 1.2
Processing industries								
Meat products	5.0	− 4.6	− 4.5	− 0.1	5.1	− 9.2	− 7.0	− 2.2
Dairy products	15.3	18.2	− 1.3	19.5	19.0	41.2	14.6	26.6
Fruit, vegetables, and seafood	12.4	27.8	30.2	− 2.4	11.6	21.9	23.0	− 1.1
Grain mill products	11.7	9.8	− 5.2	15.0	16.3	38.3	2.6	35.7
Bakery products	1.8	− 7.2	0.1	− 7.3	1.3	− 6.9	− 1.2	− 5.7
Sugar	62.4	209.3	40.6	168.7	−6.9	−30.3	20.1	−50.4
Confectionery products	24.8	66.6	82.9	−16.3	10.6	27.5	30.3	− 2.8
Beverage industries	18.4	37.9	47.5	− 9.6	9.7	14.8	18.7	− 3.9
Miscellaneous food products	4.3	− 0.2	7.7	− 7.9	3.2	− 9.5	6.1	−15.6
Tobacco manufactures	7.0	4.8	4.9	− 0.1	7.4	1.6	8.4	− 6.8
Fabric, yarn, and thread	35.7	103.9	94.7	9.2	35.3	87.5	60.4	27.1
Aggregated sectors								
Livestock and livestock products	9.2	14.6	8.4	6.2	8.7	16.1	7.5	8.6
Other agricultural products	17.5	33.0	9.5	23.5	14.2	29.5	9.6	19.9
Food and kindred products	11.5	17.3	12.4	4.9	8.9	10.5	7.9	2.6

[a] The following abbreviations are used: total nominal rate (TOT NOM), total effective rate (TOT EFF), effective tariff rate (EFF TRF), and effective nontariff rate (EFF NT).

protected these sectors are in fact taxed by the structure of tariff and nontariff policies.

A comparison of columns (3) and (4) indicates the relative importance of tariff and nontariff measures for U. S. agriculture in 1958. The effective tariff rates (which should be interpreted as measuring the effective rates of protection that the national tariff structure would provide in the absence of nontariff measures) suggest that tariff protection is significant for a number of the farm-level and processing-level sectors. On the other hand, the effective nontariff rates clearly indicate the protectionistic tendencies of domestic farm programs for the dairy, food grain, cotton, and sugar crop sectors. It is interesting to note the interaction between tariff and nontariff measures for certain sectors. For example, in the case of the confectionery products sector, nontariff measures on inputs deduct 16.3 percentage points from the rate of protection of value added afforded this industry by the tariff structure alone.

The rates of protection for 1963 allow us to analyze the manner in which protection has changed over the period 1958–1963. The feed grain commodities provide an interesting example of how policy changes have altered effective protection rates in agriculture. The policy of setting domestic support prices for feed grains above world market levels was reflected in an effective rate of 22.6 percent for the year 1958. Starting in 1963 the price support loan rates were set at approximately world levels, while both price support and acreage diversion payments were authorized for feed grains. These provisions are more consistent with trade liberalization policies and in 1963 gave rise to an effective rate of only 8.8 percent. The decline in the domestic price-support levels for grains

also affected the rates of protection for the agricultural sectors that use these commodities as inputs. For example, this policy change was the major factor leading to an increase in effective nontariff protection (i.e., lower negative rates) for the meat animal, poultry and egg, and beverage industries. Total effective protection also increased in the meat animal and poultry and egg sectors, while the total effective rate declined for the beverage industry because of a concurrent decrease in tariff duties on beverage imports.

The variations in the rates of protection accorded the sugar sectors between 1958 and 1963 perhaps warrant further explanation. Normally the domestic market price of raw sugar has been maintained above world market levels by assigning quotas to both domestic and foreign producing areas that supply the United States with sugar. This was the case in 1958, when the effective rate of protection accorded to the sugar processing industry exceeded 200 percent. In contrast, in 1963 the world market price of sugar rose sharply, and export controls were used to keep the domestic price of sugar below the world-market level. This resulted in a negative effective protection rate for the sugar processing sector. Similarly, effective protection for sugar crops declined from almost 230 percent in 1958 to about 75 percent in 1963; nevertheless, sugar act payments received by domestic producers of sugar beets and sugar cane prevented the effective protection rate from becoming negative.

Spearman rank correlation coefficients were computed to determine whether the rankings of effective protection rates had changed between 1958 and 1963. The rank correlation coefficient between the 1958 total effective rates shown in column (2) and the corresponding 1963 rates shown in column (6) is .677. The null hypothesis that the two sets of rankings are unrelated was rejected at the .05 level. Thus, even though the effective rates of protection for various sectors have changed between 1958 and 1963, their relative rankings have not been significantly altered.

Rates of protection accorded the farm-level sectors were also estimated for the year 1968. These rates, listed in Table 2, make it possible to analyze the effects of additional farm policy changes on effective protection rates in agriculture. The modifications of the wheat program in the late 1960's had little impact on effective protection afforded the food grain sector, which is dominated by wheat production. In 1968 the national price-support loan rate for wheat was set at approximately competitive world-market levels while producers received direct income payments in the form of domestic marketing certificates. These provisions resulted in an effective rate of protection for food grains of 143 percent for the year 1968. This is only slightly lower than the 1958 rate, when domestic support prices for wheat were set above world-market levels but no marketing certificates were issued.

Table 2. Nominal and effective rates of protection in the U. S. farm production sectors: 1968

Input-output sector	Total nominal (1)	Total effective (2)	Effective tariff (3)	Effective nontariff (4)
Farm-level sectors				
Meat animals	7.5	13.8	13.2	0.6
Poultry and eggs	0.8	−19.6	−16.6	−3.0
Farm dairy products	16.8	48.2	− 3.4	51.6
Other livestock products	2.5	3.3	3.5	−0.2
Food grains	8.4	143.5	− 2.7	146.2
Feed crops	0.4	8.1	0.0	8.1
Cotton	0.3	100.8	− 1.3	102.1
Tobacco	17.0	28.2	24.5	3.7
Oil-bearing crops	11.3	16.4	− 0.8	17.2
Vegetables	12.4	17.9	20.8	−2.9
Fruits	8.4	9.1	11.8	−2.7
Tree nuts	20.1	25.5	35.2	−9.7
Legume and grass seeds	6.9	8.7	11.3	−2.6
Sugar and sirup crops	195.8	662.2	72.2	590.0
Miscellaneous crops	5.8	13.0	15.2	−2.2
Forest products	0.0	− 0.9	− 0.1	−0.8
Greenhouse products	3.7	3.2	4.4	−1.2
Aggregated sectors				
Livestock and livestock products	8.5	18.9	7.5	11.4
Other agricultural products	7.6	32.3	6.0	26.3

Revisions were also made in the U. S. cotton program between 1963 and 1968. By 1968 market support of cotton was lowered to approximately competitive world-price levels while incomes of producers were supplemented by use of direct price-support and acreage diversion payments. These revisions appear to have contributed to a rise in the effective protection level for cotton. The total effective rate for cotton was estimated to be about 100 percent in 1968; the corresponding rates were 57 percent in 1958 and 95 percent in 1963.

It is interesting to note that the effective rates of protection have declined between 1958 and 1968 in the vegetable, fruit, tree nut, and greenhouse and nursery product sectors. Nontariff distortions have generally been unimportant for these sectors.

Spearman correlation coefficients for the farm-level sectors also reveal a significant degree of association between rankings of effective protection rates in different years over the

Table 3. Nominal and effective protection rates in U. S. crop production: 1958, 1963, 1968

Input-output sector	1958		1963		1968	
	Total nominal	Total effective	Total nominal	Total effective	Total nominal	Total effective
Wheat	40.0	139.7	42.3	159.9	8.6	153.0
Rye	43.7	168.3	0.0	−15.8	0.0	−16.5
Rice	44.0	151.7	36.4	120.4	7.3	13.7
Buckwheat	5.3	7.0	3.6	1.0	1.4	− 4.3
Corn	11.4	19.3	0.0	7.6	0.0	20.0
Oats	26.5	67.7	0.0	−16.9	0.0	−15.8
Barley	19.4	40.7	0.0	− 1.4	0.0	−13.2
Sorghum	23.7	43.3	0.0	8.0	0.0	23.5
Soybeans	0.0	−5.1	0.0	− 6.8	0.0	− 6.7
Peanuts	37.3	102.7	71.4	203.3	69.3	204.0
Flaxseed	22.8	47.4	2.2	− 5.7	14.8	26.2
Cotton	19.8	57.1	32.2	95.0	0.3	100.8
Tobacco	11.7	19.0	15.0	24.4	17.0	28.2
Sugar crops	57.4	227.7	−6.3	72.6	195.8	662.2

period 1958–1968. The rank correlation between the 1958 and 1963 total effective rates is .882 while the corresponding coefficients for the 1958–1968 and for the 1963–1968 rankings are .882 and .919, respectively. Further analysis, however, reveals that significant changes have occurred in the pattern of protection for individual commodities within the major crop sectors.

Table 3 presents nominal and effective rates of protection involving 14 crop commodities for the years 1958, 1963, and 1968. Notice the substantial variation in these rates of protection between 1958 and 1968. The Spearman rank correlation coefficient between the 1958 effective rate of protection rankings for these farm crops and the corresponding 1963 rankings is .323; similarly, the rank correlation between the 1958 and 1968 rates is .279. On the other hand, the Spearman coefficient between the 1963 and 1968 rates is substantially higher at .811. In the first two cases the null hypothesis that the rankings are unrelated was accepted at the .05 level of significance. These results are not surprising since major farm policy changes, involving many of these individual crops, have occurred between 1958 and 1968.

Rank correlations were also computed to measure the degree of association between changes in effective protection rates and changes in output for the farm crops shown in Table 3. The Spearman coefficient between the rankings of percentage changes in effective rates over the 1958–1963 period and the corresponding rankings of percentage changes in output is .560. By coincidence the rank correlation between the 1958–1968 effective rate changes and the 1958–1968 output changes is also .560. In both cases the null hypothesis of no relation was rejected at the .05 level.

Summary and Conclusions

This investigation was undertaken in an attempt to help fill a void in the literature pertaining to the levels of protection in agricultural industries of various countries. In particular, the theory of effective tariff protection was extended by introducing nontariff trade distortions and domestic farm policy measures. Then, as an application of this concept of protection, effective protection rates were calculated for disaggregated U. S. agricultural production and processing industries for the years 1958, 1963, and 1968. In the past these sectors have usually been excluded from such analysis.

The rates of protection reported in this paper reveal certain general features: (1) the nominal and effective rates of protection for a particular industry are often considerably different; (2) effective protection rates vary greatly from one agricultural sector to another; and (3) nontariff distortions give rise to extremely high effective protection in certain agricultural sectors, while in others tariff and nontariff measures affecting intermediate inputs have important taxation effects. High effective tariff rates, on the other hand, were notable for several other agricultural sectors. The analysis also indicates that a significant level of correlation exists between rankings of effective protection rates in different years over the period 1958–1968 when all of the agricultural sectors are considered. However, the opposite conclusion was reached when the analysis focused upon individual farm crop sectors involved in agricultural policy changes. Finally, Spearman rank correlation coefficients reveal a substantial degree of association between changes in effective-rate rankings for individual farm crops and the corresponding rankings of actual changes in crop production.

Although the absolute magnitudes of the effective rates of protection in certain U. S. agricultural industries appear to be quite high in some cases, they are likely to be equaled or exceeded by rates of protection in the agricultural sectors of other industrially developed nations. For example, as reported in a recent

UNCTAD study [5], many of the nominal ad valorem equivalents for variable levies which affected agricultural commodities imported by the EEC during 1967 exceeded 50 percent, approaching 300 percent in the extreme case of butter. These nominal rates could lead to extremely high effective rates of protection. In the future it may be desirable to extend this analysis to a comparative study of agricultural protection in a number of the industrially developed nations.

In conclusion, something should be said about the rather rigorous assumptions underlying the empirical analysis of this paper. The use of input-output data imposes a crucial assumption with respect to substitutability of inputs in production. In addition, the assumption regarding the relationship between domestic and foreign prices may well be a poor approximation of reality. Thus the results should be interpreted with a certain degree of caution. Yet it still seems useful to compute effective rates of protection. Unlike the traditionally reported nominal rates of protection, effective protection rates do take into account the effects of tariff and nontariff distortion measures on intermediate inputs as well as on final output. In addition, effective rates of protection must be considered better indicators of resource shifts than nominal rates.

Appendix

Data Sources and Computational Procedures

Input-output data for the 17 primary agricultural sectors were obtained from unpublished background tables prepared by the U. S. Department of Agriculture in conjunction with the 1958 input-output tables published by the Department of Commerce. Additional unpublished data furnished by the USDA were used to further disaggregate many of the input items used by the primary agricultural sectors. These data made it possible to identify many of the individual farm level inputs; in addition, many nonagricultural inputs were identifiable at the four-to-six digit level of the Standard Industrial Classification (SIC) code. The input-output data for the processing industries were taken from additional input-output detail published by the Department of Commerce [9]. Here again, additional information procured from the Department of Agriculture was utilized to further disaggregate the inputs purchased by the processing industries.

The data needed to compute the various nominal rates of protection entering the effective-protection formulae were taken from numerous sources. Information on duties, value of imports, and transportation costs to U. S. ports for individual primary agricultural commodities was supplied by the USDA for the years 1958 and 1963. These data were supplemented with information contained in the U. S. tariff schedules. Data for the 1958 and 1963 tariff rate calculations for the processed products and nonagricultural inputs were published by the Department of Commerce [6, 7]. Information on imports and duties for 1968 was available for individual tariff schedule commodities [8]. A cross classification between SIC and TSUSA (Tariff Schedules of the United States Annotated) numbers was used to obtain a correspondence between these data and the input-output industries. The data on duties collected, foreign port value of imports, and transportation costs to U. S. ports were used to compute nominal tariff rates expressed in terms of c.i.f. value. When data on freight and insurance costs were not available for individual commodity items, the ratio of f.o.b. to c.i.f. import values given for commodity groups in the 1958 input-output study were employed to correct for f.o.b. valuation practices.

Nontariff distortions were handled in a number of different ways. For example, tariff equivalents were computed for the commodities affected by the domestic price support provisions which maintain domestic market prices above competitive world markets levels. In most cases the tariff equivalents were determined by finding the ratio of the U. S. export subsidy to the domestic price net of the subsidy. For importables, the tariff equivalent was computed as the percentage difference between domestic and competitive import prices.

The 1958 excise tax rates were calculated from supplementary input-output data showing the distribution of excise taxes by consuming sectors. The corresponding tax rates for 1963 and 1968 are based on Internal Revenue data giving changes in rates on various taxed items.

Total nominal rates for the input-output sectors were obtained by weighting the tariff and nontariff rates for individual products by their relative importance in domestic output. Similarly, whenever aggregation was necessary, domestic output values were used to construct average tariff and nontariff rates.

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The Value, Cost, and Efficiency of American Food Aid*

Per Pinstrup-Andersen and Luther G. Tweeten

Theoretical frameworks were developed to estimate the value to recipient countries of food aid relative to untied cash aid, the cost to the donor country, and the social gain realized by channeling surplus productive capacity in the agricultural sector into food aid rather than reducing production. On the basis of these frameworks, the value, cost, and social gains associated with U. S. food aid during 1964-1966 were estimated. The value to recipient countries of food was estimated to be 80 percent of its world market value. The present value of repayments, interest payments, and transportation costs payable by food aid recipient countries was found to exceed the actual value of food aid under the prevailing dollar credit programs. Hence, a net transfer of resources from developing countries to the United States was found to occur. The cost to the United States of maintaining food aid programs during 1964-1966 was estimated to be approximately equal to the cost of reducing production by a similar amount, using voluntary land retirement programs. It was found that evaluation and pricing of U. S. food aid on the basis of the prevailing export prices results in a considerable overstatement of the actual value to the recipient countries and causes unduly high repayment obligations.

Knowledge of the value to recipient countries of food aid relative to the value of other types of aid, as well as the opportunity costs to the United States of the two types of aid, is necessary to determine an optimum mix of food and nonfood items in U. S. economic assistance programs as well as an optimum allocation of U. S. food surpluses.

It is often assumed that food aid valued at domestic prices or at export prices provides benefits to the recipient country equivalent to aid in any other form. Likewise, it is often assumed that food aid entails little or no resource cost to the United States because surplus capacity exists in agriculture.

Clearly the concept of opportunity cost is central to an economic evaluation of food aid. A few studies have recognized this. Tweeten [13] developed a theoretical framework that specifies (a) the optimal allocation of resources between providing farm commodities versus other forms of aid to developing countries and (b) the optimal combination of production control and disposal in foreign countries as a means of handling reserve capacity in U. S. agriculture. The model can be used to determine the optimal combination of food aid, nonfood aid, and voluntary domestic production control at a given government cost, either (a) to maximize domestic net farm income while holding the real level of foreign aid constant or (b) to maximize real foreign aid while holding domestic net farm income constant.

Pincus [7] estimated the cost of the various types of U. S. foreign aid and Hillman and Loveday [1] suggested a theoretical framework to estimate the optimal combination of surplus disposal and supply control. Furthermore, Schultz [11] estimated the aggregate value in the late 1950's of U. S. farm surpluses to recipient countries.

The theoretical models developed in previous efforts must be substantially extended to facilitate a comprehensive empirical analysis. The major objectives of this study are:

(1) To develop a conceptual framework to estimate the value to recipient countries of food aid relative to untied cash aid and to estimate the value of U. S. food aid by means of this framework for 1964–1966.

(2) To develop a conceptual framework to estimate the cost to the donor countries of food aid relative to the best alternative outlet for surplus commodities and to estimate the cost of U. S. food aid on this basis for 1964–1966.

(3) To estimate the social gain associated with food aid programs and its distribution between donor and recipient countries for 1964–1966.[1]

Following a discussion of the data sources, we present empirical estimates of the real costs and benefits for the three major types of U. S. food aid (grants, credit sales, and nonconvertible currency sales) and for the total actual 1964–1966 aid comprised of these three types. The conceptual framework for each estimate

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[1] The social gain is defined as the value of food aid to recipient countries less its value in its best alternative use.

is presented with the empirical results; a more rigorous conceptual framework is found in the Appendix.

Data Sources

The basic data were obtained from a mail survey covering 14 countries. All countries that received one percent or more of the total U. S. food aid during 1964–1966 were included in the sample, provided that they had diplomatic relations with the United States when the research was initiated. The survey countries received 70 percent of total U. S. food aid during 1964–1966.

Potential individual contacts were chosen after consultation with a large number of individuals and agencies, some American and some in the sample countries. Only individuals with a considerable knowledge of economic development and external economic assistance programs and needs were included. Of the 441 persons contacted, a partly or fully completed questionnaire was received from 88, an overall response rate of 20 percent. Some of the 88 replies represented joint responses. Of the 88 respondents, 72 were citizens of the countries surveyed and 16 were U. S. citizens. The latter were foreign development experts living in the survey countries. Of the former, 46 were economists and/or political scientists, most of them affiliated with universities; 7 were cabinet members; 8 were government officials; 11 had other professions.

The questionnaire covered a number of aspects of U. S. foreign assistance programs. Only those results that refer to the value of food aid are reported here.[2]

Each survey participant was asked to indicate for three levels of food aid for 1964–1966 the amounts of untied cash aid that he believed would have been of equal benefit to the particular country. The three levels of food aid were (1) the actual amount received valued at world market prices, (2) an additional amount of $1 million annually, and (3) an amount 25 percent above that actually received. The *average value* of food aid was estimated as the inverse ratio of the actual amount of food aid to the amount of equivalent untied cash aid indicated.

The untied cash aid believed to be of the same benefit as an additional $1 million of food aid may be interpreted as the marginal value of food aid where the marginal unit is $1 million. The cash aid equal to a 25 percent increase in food aid may be interpreted similarly. Assuming that the marginal value per dollar of food aid was a linear function of the quantity of food aid which might have been received beyond the actual amount, the *marginal value* (the value of the last dollar of food aid received) was then estimated by means of linear regression.

How efficient was the sample? Some indication can be obtained by computing standard errors—the clustering of responses about the mean. The standard errors were computed for estimates of the marginal value of food aid as a percentage of the export value for eight countries from which five or more questionnaires were obtained.

The standard errors ranged from 5.8 percent for Brazil to 8.8 percent for Chile. We believe these figures reflect considerable agreement among respondents. Of course, a small error does not rule out bias; respondents could have consistently overestimated or underestimated the value of food aid.

While shortcomings of data suggest caution in interpreting results, we believe the estimates to be useful. Furthermore, we are unaware of other comprehensive estimates of the value of food aid. Finally, we are unaware of any alternative methodology that would offer more reliable estimates of the value of food to recipient countries at a manageable research cost. While these estimates are neither final nor exact and further refinements are desirable, the estimates do reflect the views of selected and presumably informed foreigners and Americans about the value of U. S. food aid.[3]

Average and Marginal Value of Food Aid to Recipients

Table 1 shows the estimated marginal and average value of U. S. food aid for each of the survey countries. Each estimated value shows the worth of food aid to the recipient country as a percentage of the face value[4] of the aid at the margin and on the average, respectively.

The estimate for each country was weighted by the amount of food aid received to obtain the weighted mean of the country averages.

[2] For a discussion of findings on the impact of food aid on commercial food export, see [9].

[3] For a more complete presentation of primary and secondary data sources and limitations, see [8].

[4] Face value is defined as the value determined on the basis of prevailing world market prices.

Table 1. Estimated value of U. S. food aid in percent of prevailing world market prices and the aid components present for each of the survey countries, 1964–1966

Country[a]	Average value	Marginal value	Cost of transportation[b]	Estimated aid component[c]: 20-year credit		40-year credit		Nonconvertible currency			Actual program mix[f] 1964–1966
				Average	Marginal	Average	Marginal	Average	Marginal[d]	Marginal[e]	
India	90.6	73.1	22.5	1.0	−16.5	8.2	− 9.3	53.1	50.6	35.6	53.1
Pakistan	[g]	100.0	16.9		16.0		23.2		83.1	74.3	
Yugoslavia			14.5								
Brazil	69.0	67.2	17.2	−15.3	−17.1	− 8.1	− 9.9	33.7	50.0	31.9	27.2
Korea, Republic of	68.6	81.4	20.9	−19.6	− 6.6	−12.2	0.6	32.5	60.5	45.3	34.6
Turkey	65.4	70.6	12.7	−14.4	− 9.2	− 7.2	− 2.0	22.8	57.9	28.0	24.6
China, Republic of	70.3	68.4	21.3	−18.1	−20.0	−10.9	−12.8	25.0	47.1	23.1	12.9
Israel	85.9	80.5	13.4	5.4	0.0	12.6	7.2	57.5	67.1	52.1	52.9
Greece	84.3	77.9	12.9	4.3	− 2.1	11.5	5.1	37.1	65.0	30.7	22.5
Chile	80.9	78.4	12.9	0.9	− 1.6	8.1	5.6	42.0	65.5	39.5	31.7
Morocco	100.0	88.3	13.7	19.2	7.3	26.4	14.7	62.3	74.6	50.6	57.5
Congo (Kinshasa)	100.0		24.1	8.8		16.0		62.9			62.2
Indonesia			22.5								
Colombia	70.9	73.1	13.7	− 9.9	− 7.7	− 2.7	− 0.5	29.8	59.4	32.0	28.6
Weighted average	79.6	76.9	19.3	− 6.8	− 9.5	0.4	− 2.3	36.7	57.6	34.0	43.2

[a] The survey countries are ranked according to the amount of food aid received during the three fiscal years 1964–1966. For the amounts see [8].
[b] The cost of transportation is shown as a percentage of the value of the food aid on the basis of prevailing world market prices. The rates on foreign vessels are used.
[c] See Appendix equations (1)–(9) for aid component formulas.
[d] It is assumed that the U. S. requirements for nonconvertible currencies are satisfied prior to the receipt of the last unit of currency.
[e] It is assumed that the same proportion of the last unit of currency is used in place of dollar spending as for all previous units.
[f] Average aid components. The aid components in grants is included in the actual program mix but is not listed in separate columns because the estimates are the same as those in the columns labeled "average value" and "marginal value."
[g] Blanks indicate that the estimate was not available.

This weighted average for 11 countries was estimated to be 80 percent on the average and 77 percent at the margin (Table 1). This implies that the survey countries would have been equally well off during 1964–1966 receiving either the actual amount of food aid as donations or an amount of cash aid equal to 80 percent of the world market value of the food aid.

The Aid Component

To perform realistic evaluations and comparisons of various types of foreign assistance programs, a universal unit or common denominator is needed. The common denominator used here is the aid component. The aid component present in foreign economic assistance is defined as the real value of the gross flow of money, goods, and services to a recipient country less the discounted present values of the required disbursements (repayments, etc.).[5]

Grants

The aid component included in food grants consists of the real value[6] of the food less transportation costs payable by recipient countries. Under the grant program the total cost of transportation is paid by the United States. Since no other disbursements are required of grant recipients, the average and marginal aid components expressed as a percentage of the face value of the aid are equal to the average and marginal values, respectively, as shown in the first two columns of Table 1.

Sales on long-term dollar credit

The aid component present in sales on long-term dollar credit may be expressed as the real value of the food received less (a) transportation costs payable by the aid recipient and (b) the discounted present value of down payment, principal repayments, and interest payments (see Appendix). Most agreements under this program are based on either a 20-year or a 40-year repayment period, with a grace period of 2 and 10 years. A down payment of 5 percent of the total value of the commodities is stipulated. The interest rate is 2 percent during the grace period and 2.5 percent of the unpaid balance during the remaining years.

The present value of disbursements was calculated for each of the two credit arrangements using a discount rate of 6.5 percent and a 10 percent rate of default.[7] The estimated aid components expressed as a percentage of the

[5] Disbursements, as applied in this case and in later analyses, refer to the total payment required from aid recipients, including transportation costs if paid by aid recipients.

[6] The real value is given by the average value of food aid, as previously estimated, multiplied by the face value of the total aid provided under the particular aid program.

[7] See Appendix for a discussion of the choice of interest rate and rate of default.

face value are presented in Table 1. The aid component was small and varied considerably among countries. This is due to differences in the need for food relative to other types of aid, the aid terms, and the transportation cost.

In general, the aid component present in the last unit of food aid was found to be lower than the average aid component. This implies that, given the prevailing amounts of food and nonfood aid, the efficiency of food aid relative to other types of aid is decreasing as food aid is expanded.

A negative average aid component in Table 1 implies that if the countries have access to loans carrying a rate of interest of 6.5 percent, they would have been better off rejecting food aid on long-term dollar credit.

The weighted mean of the average aid component for the survey countries was found to be −6.8 under the 20-year terms. This means that the recipient countries paid 7 cents more for each dollar's worth of food, where worth is expressed by prevailing world market prices, than its real value to them. The recipient countries would break even, i.e., the aid component would be zero if the countries paid back only three-fourths of the credit—a default rate of 25 per cent.

Sales for nonconvertible currencies

The aid component present in sales of U. S. food for nonconvertible currencies is defined as the real value of the food less (a) transportation costs payable by aid recipients and (b) the amount of dollar spending in the recipient country displaced by the local currency obtained (see Appendix).

The aid component is considerably larger for food sold for nonconvertible currencies than for food sold on dollar credit, according to results presented in Table 1. The average aid component present in U. S. food aid sold for nonconvertible currencies during 1964–1966 was estimated to be 36.7 percent of the face value of the aid. The aid component present in the last unit of aid was estimated to be 57.6 percent of the face value if it is assumed that the U. S. requirements for nonconvertible currencies are satisfied prior to the receipt of the last unit of currency. If, on the other hand, it is assumed that the same proportion of the last unit of currency is used in place of dollar spending as for all previous units, then the aid component present in the last unit was estimated to be 34.0 percent of the face value. It is likely that the amount of nonconvertible currency replacing dollar spending for any individual country was somewhat fixed and affected little by additional currency in the 1964–1966 period. Thus, the former assumption appears to be more valid.

The actual program mix, 1964-1966

Based on the amount of food aid actually received under each of the three programs, the average aid component was estimated for each of the survey countries and was expressed as a percentage of the face value of the 1964–1966 food aid in Table 1. The survey countries would have obtained the same benefit from 43 cents of untied cash aid as from $1 of food aid during 1964–1966.

It was estimated that India, which was the major food aid recipient during 1964–1966, would have gained equal benefits from either 53 cents of untied cash aid or $1 of food aid. The relatively high real value of food aid to India is partly explained by the high value of food relative to cash aid, as earlier indicated, and partly by the fact that India received all her food aid under two programs, sales for nonconvertible currency and grants, both of which have a high aid component.

Net Costs to the Donor Country

Two alternative outlets for surplus commodities presently exported under aid programs—commercial export and production control—were analyzed in the original study [8].[8] Only production control is included in this article, in order to reduce the volume of material.

The net cost to the United States of food aid if production control is the best alternative outlet for the food included in the programs, may be estimated as (a) the savings that the United States could have realized by reducing production by the amount of food exported under aid programs, i.e, revenue foregone by maintaining the food aid programs, plus (b) transportation costs on food aid payable by the donor country, less (c) the present value of the disbursements made by the aid recipients.[9] (See Appendix for formulas.)

[8] We assumed that any agricultural program would need to maintain farm income; hence, a free market that would allow prices to fall was not considered.

[9] Using as discount rate the average returns from public investment in the United States instead of the previously used World Bank lending rate. Krutilla and Eckstein's estimate of 5.5 percent was used in this study [2].

The estimated net costs for each of the major aid programs are shown in Table 2. The net costs are based on a function describing the relationship between the efficiency of government programs to reduce production and the level of acreage diversion. On the basis of this function, the treasury cost required to reduce farm output by $1.00 could be estimated for any level of food aid. The cost ranged from approximately 25 cents for low acreages to $1.00 at 80 million acres.

Table 2. Estimated net cost of U. S. food aid under each of the various aid programs, 1964-1966[a]

Aid program	Average net cost	Marginal net cost
Sales on dollar credit		
20-year terms	−45.6	−35.6
40-year terms	−38.9	−28.9
Nonconvertible currency	3.0	13.0
Grants	45.9	55.9

[a] The net cost is expressed in percent of the face value of the aid. See Appendix equation (12) for formulas.

The net cost of exporting food under long-term dollar credit was found to be negative; i.e., the present value of the disbursements made by aid recipients exceeds the revenue foregone by not curtailing production. If all food aid were exported on long-term dollar credit and production control were the best alternative, the United States would realize an average gain equal to 45.6 percent of the face value of the aid under 20-year terms and 38.9 percent under 40-year terms by allocating the surplus capacity to foreign aid rather than to production controls.

If all food aid were sold for nonconvertible currency, the net cost to the United States was estimated to be 3 percent of the face value of the aid. Finally, if no disbursements were required, the net cost was estimated to be 45.9 cents per dollar's worth of food aid.

The gains at the margin were found to be somewhat lower than the average gains, primarily because of a negative correlation between the efficiency of U. S. government programs in reducing farm production and the level of reduction attempted.

Social Gain

The average net social gain expresses the net addition to social output obtained by maintaining the food aid programs during 1964–1966 rather than allocating the food aid commodities to the best alternative use. If production control were considered the best alternative, the estimated average net social gain realized by maintaining food aid programs would be between 39.3 and 33.7 percent of the face value of the aid (Table 3).

Table 3. Estimated average and marginal net social gain of food aid in percent of face value and their distribution between donor and recipient countries, 1964-1966[a]

Aid programs	Average net social gain			Marginal net social gain		
	Total	Aid recipient	Donor	Total	Aid recipient	Donor
Sales on dollar credit						
20-year terms	38.8	− 6.8	45.6	26.1	− 9.5	35.6
40-year terms	39.3	0.4	38.9	26.6	− 2.3	28.9
Nonconvertible currency	33.7	36.7	− 3.0	21.0	34.0	−13.0
Grants	33.7	79.6	−45.9	21.0	76.9	−55.9

[a] See Appendix equations (11)–(14).

The distribution of social gain between donor and recipient countries is shown by the aid component and the net cost. The aid component indicates the net gain obtained by the recipient country. Hence, the net social gain less the aid component indicates the net gain obtained by the donor country. The size of the aid components and the net cost for each program have been discussed previously.

The net social gains realized under credit arrangements exceeded those obtained under other aid programs. This phenomenon is due to imperfections in the international money market. The returns to capital under equal risk is higher in the recipient countries than in the donor country. Hence, the social gains realized under credit arrangements consist of (a) the gains obtained by allocating the commodities to food aid rather than to the best alternative outlet plus (b) the gains obtained by reallocating capital from lower to higher returns.

The net gain obtained by aid-recipient countries indicates the amount of cash aid (grants) that would have had an impact on economic progress equal to the impact obtained by the food aid.[10] Or the net gain may be viewed as the benefit obtained by the recipient countries in excess of the potential benefits available from borrowing an amount of money equal to the face value of the food

[10] In Table 3 the amount of cash aid is given as a percentage of the face value of the food aid.

aid at the rate of interest equal to the discount rate used.

The net gain obtained by the donor country indicates the revenue obtained from surplus commodities used for food aid in excess of the revenue obtainable from the best alternative use of the surplus commodities.

As shown in Table 3, the net social gains are somewhat lower at the margin than on the average. Hence, the contribution of the last dollar's worth of food aid to social outputs is lower than the average contribution.

An Analysis of Total U. S. Food Aid During 1964-1966

Results of an analysis of total U. S. food aid during 1964–1966 are shown in Table 4. The average annual value of the total U. S. food aid during 1964–1966 was reported as $1,569.4 million. Since the value of grants is reported on the basis of total CCC costs, the face value of the aid, i.e., the value based on prevailing export prices, was somewhat smaller—$1,473.7 million. Assuming that the average rate of substitution for major aid recipients shown in Table 1 is valid for all U. S. food aid, the real value to the recipient countries was an estimated $1,173.1 million per year. However, disbursements were required.

The present value of down payment, repayments, and interest payments was estimated at $418.6 million annually when the estimation was based on a discount rate reflecting alternative cost of capital to recipient countries and $430.6 million when based on the U. S. alternative cost of capital.

The cost of transportation paid by food aid recipients was estimated to be $258.9 million annually. This amount covered the cost of shipping food aid commodities received under Title I (dollar credit and nonconvertible currency) on foreign vessel. If the aid commodities were shipped on U. S. vessels, the United States paid the transportation costs in excess of those charged by foreign vessel. We consider these costs to be a subsidy to the U. S. merchant marine independent of food aid considerations. Hence, we did not include them in our calculations.

The United States paid the total shipping cost related to food donations. Using the foreign vessel rates, these costs were estimated to be $25.5 million annually.

The value of aid to recipient countries, less the present value of disbursements and transportation, gives a net value of U. S. food aid to recipient countries totaling $495.6 million annually in the 1964–1966 period (Table 4). This was only 34 percent of the face value of the aid.[11,12]

The government cost of food aid was $1,569.4 million annually for commodity purchases plus $25.5 million for transport costs less the present value of recipients' disbursements, $430.6 million, or $1,164.3 million.

Instead of food aid, the U. S. Government could have chosen voluntary production control. The government cost of reducing production by an amount equal to that shipped under PL 480 during 1964–1966, while leaving U. S.

Table 4. Reported value, cash equivalent, net cost, and social gain of total U. S. food aid, 1964-1966

	Percent of face value	Annual average (*million dollars*)
Reported value[a]	106.5	1,569.4
Face value[b]	100.0	1,473.7
Value to recipient countries	79.4	1,173.1
Disbursements required (United States)[c]	29.2	430.6
Disbursements required (Recipients)[d]	28.4	418.6
Cost of transportation (paid by United States)	1.7	25.5
Cost of transportation (paid by recipients)	17.6	258.9
Cash equivalent (aid component)	33.6	495.6
Revenue foregone[e]	28.3	417.5
Net cost to the United States	.8	12.4
Social gain	32.8	483.0

[a] As reported by U. S. Government.
[b] Evaluation based on prevailing export prices.
[c] The present value of down payment, repayments, and interest payments, using as discount rate the alternative cost of capital to the United States.
[d] As above, except that the discount rate reflects the alternative cost of capital to aid-recipient countries.
[e] Assuming that production control was the best alternative outlet for excess productive capacity.

[11] The difference between the estimated aid component for the survey countries and that for the total aid is due to a considerable difference in the proportion of the nonconvertible currency used to replace dollar spending in the survey countries and the countries not surveyed.

[12] Transportation costs were subtracted from the gross to arrive at this net value because other forms of real aid would have required less transportation cost per dollar of real aid (e.g., technical assistance). If transportation costs are excluded under the assumption that they would accrue in equal magnitude under all forms of real aid, then the cash equivalent value of foreign aid was 51 percent of the reported value of the aid.

net farm income unchanged, would have been \$1,151.9 million annually.[13]

Thus, the net cost to the United States from PL 480 rather than production control was \$1,164.3–\$1,151.9 = \$12.4 million, or .8 percent of the face value of food shipments.

Conclusions

The results obtained in this study indicate that the use of U. S. food, feed, and fiber "surpluses" as foreign aid during 1964–1966 resulted in a greater contribution to world social output than if production had been reduced.

The distribution of the net social gain between donor and aid recipients was determined by the terms of the aid. It was found that the entire net social gain accrued to the recipient countries if the food aid was traded for nonconvertible currencies or received as donations. In addition, a net transfer of resources from donor to recipient countries was estimated to have taken place under these programs. Conversely, under credit arrangements, the U. S. obtained the entire net social gain. Furthermore, it was found that unless the rate of default of the credit was high, a net transfer of resources from the aid recipient countries to the donor country would take place. This finding appears to contradict conventional knowledge and beliefs on which foreign economic assistance programs are based. If foreign aid is defined as a net transfer of resources from a more developed country to a less developed country, the long-term dollar credit arrangements do not qualify as aid programs, according to the results from this study.[14]

The use of the value of food aid, as currently reported, as an indicator of the flow of actual aid to developing countries is very misleading. Neither prevailing export prices nor CCC costs reflect the real value of food aid to recipient countries. Nor are the required disbursements from aid recipients taken into consideration.

Prevailing export prices or CCC costs utilized as value indicators for food aid misinform the public and can lead to a smaller total flow of real aid to developing countries than would be desired by the U. S. public. From the point of view of the U. S. legislators, the reported value of the aid flow indicates the actual aid contribution. However, if the reported value is inflated, the amount of real aid is less than what the legislators were actually willing to contribute. If the value of food aid is not correctly reported, other types of aid may be misallocated. Furthermore, the share of the total economic assistance provided by any one donor country may not be correctly reported. For a country where the ratio of food to nonfood aid is high, the reported share is upward biased, ceteris paribus. The same problem exists in nonfood aid where the face values of loans and grants are lumped together as "aid."

One way to provide correct information concerning the value of foreign aid flows would be to evaluate and report all foreign economic assistance on the basis of the value to recipient countries less the disbursements required, i.e., the aid component—the amount of untied cash aid (convertible currency) of equal benefit to recipients.

Pricing of commodities exported under aid programs that require repayment either in nonconvertible currency or dollars, on the basis of prevailing world market prices, causes unduly high repayment obligations.

It is suggested that repayments of food aid be based on the revenue foregone by the donor country by allocating the commodities to food aid rather than to the best alternative use, e.g., production control. This would preclude a net reverse transfer of resources. Furthermore, the total social gain would be obtained by the aid recipients. The real cost to the donor country would be limited to the difference between the interest charged on the credit and the opportunity cost of capital.

Because of increasing emphasis in export on long-term dollar credit (a program that may have a negative aid component) it appears that correct pricing and evaluation of food aid in the future is extremely important if a high degree of efficiency in foreign economic assistance is to be obtained.

Appendix

The following analysis expresses mathematically a number of concepts used in the text, including the aid component, the net social cost, and the net social gain.

[13] The cost associated with voluntary production control is given by the cost of commodity purchased, \$1,569.4 million, less revenue foregone, \$417.5 million.

[14] The developing countries' acceptance of aid programs with a negative aid component may be due to lack of information or to the weak bargaining position of these countries. The only alternative to accepting the food aid may be mass starvation. Furthermore, the recipient country may be preoccupied with the short-run situation; hence, the amount of repayment may be of little significance at the time of the aid transaction.

Aid component in long-term dollar credit sales

The aid component present in sales on long-term dollar credit may be expressed as the real value of the goods received less transportation costs payable by the aid recipient and the discounted present value of down payment, principal repayments, and interest payments.

Let Q be the quantity of food involved in a trade transaction and P_w the world market price in dollars per unit prevailing at the time of trading. Then QP_w is the face value of the commodities traded in dollars. The estimated average value of food aid expressed as a percentage of world market value is called AV and the estimated marginal value of food aid called MV. AV and MV are estimated on the basis of a survey, as discussed in the section on data sources.

If the discounted present dollar value of down payments, repayments, and interest payments is PV, then the total aid component A_1 present in the 1964–1966 food aid is

$$A_1 = QP_w(AV) - T_1 - (PV) \tag{1}$$

where T_1 is transportation costs payable by recipient countries. The aid component at the margin A_2 for 1964–1966 food aid is

$$A_2 = QP_w(MV) - T_{1M} - (PV_M) \tag{2}$$

where T_{1M} and PV_M refer to the marginal unit.

The average aid component expressed as a percentage of the face value of the credit is

$$a_1 = \frac{A_1}{QP_w}100 = AV - \frac{(T_1 + PV)}{QP_w}100. \tag{3}$$

Likewise, the marginal aid component as a percentage of the face value is given by

$$a_2 = MV - \frac{(T_{1M} + PV_M)}{QP_w}100. \tag{4}$$

Various formulas express the present dollar value (PV) of disbursements under various circumstances. It is assumed that the world market prices prevailing at the time of trading are used to determine the amount of credit to be repaid (QP_w). This is usually the case for transactions under PL 480.

Since there may be some doubt as to the ability of the recipient countries to repay the credit obtained on commodities for direct consumption, a coefficient indicating the expected rate of default (D) is included in the computations. The coefficient indicates the expected percentage of the credit that will not be repaid. As the default rate increases, the aid component included in the credit will increase, ceteris paribus.

One reason for including a default rate (rather than including the risk element in the discount rate r) is that the probability of complete repayment of long-term credit on commodities for direct consumption may be smaller than the probability of complete repayment of loans for investment purposes. By introducing the default rate to cover only the difference in risk between investment loans and consumption credit, the discount rate r is directly comparable to the opportunity cost of capital for investment purposes. Thus, the World Bank's lending rate of 6.5 percent may be used as the rate of discount.

At the time of the study the credit arrangements had been recently introduced. Available historical evidence did not lend itself to a projection of the future rate of default.

A model was developed to determine the aid component as a function of the default rate. Hence, although the results reported here are based on an arbitrary selected default rate of 10 percent, estimates based on other default rates may be easily obtained. A 1 percent increase in the default rate increases the aid component approximately .5 percentage points for the 20-year arrangement and .2 percentage points for the 40-year arrangement.

The default rate is introduced into the model with the assumption that the probability of default is the same for any one year during the repayment period. There is some indication that defaults usually are limited to the repayments of principal. We assumed that all interest payments will be paid on time.

The present value of down payment, repayment of principal, and interest payment for a loan with a grace period of n' years and a total duration of n years is given by

$$\begin{aligned} PV = {} & i_1(QP_w - I)[(1+r)^{n'} - 1] \\ & [r(1+r)n']^{-1} + I + \sum_{t=n'+1}^{n} \\ & \Big[[(QP_w - I)(1-D)](n-n')^{-1} \\ & + i_2(QP_w - I) \\ & [1 - (t - n' - 1)(n - n')^{-1}] \Big] \\ & (1+r)^{-t} \end{aligned} \tag{5}$$

The first part of the equation relates to the

interest payment during the grace period, I is the down payment and the remaining terms include the interest and repayment of principal during the repayment period $n-n'$.[15]

The rate of interest during the grace period and repayment period is given by i_1 and i_2 respectively and r is the discount rate.

The remaining variables were defined previously.

Aid component in sales for nonconvertible currencies

The aid component present in sales of U. S. food for nonconvertible currencies consists of the actual value of the food less transportation payable by aid recipients and the amount of dollar spending in the recipient country displaced by the local currency obtained. An estimate of the total aid component included in sales for nonconvertible currencies is

$$(6) \qquad A_1 = QP_w(AV) - T_1 - B$$

where Q, P_w, T_1, and AV are as previously defined and B is the amount of dollar spending displaced by local currency in the recipient country.

The aid component at the margin is given by

$$(7) \qquad A_2 = QP_w(MV) - T_{1M} - (MB)$$

where MB is the amount of dollar spending substituted by the local currency obtained at the margin.

Aid component in grants

The aid component included in food grants consists of the real value of the grant less transportation costs payable by recipient countries. As before, the real value is estimated by the average value of food relative to untied cash aid. Thus, the aid component present in food grants is

$$(8) \qquad A_1 = QP_w(AV) - T_1.$$

The aid component at the margin is

$$(9) \qquad A_2 = QP_w(MV) - T_{1M}.$$

Net costs of food aid to the donor country

Ignoring government storage costs, the revenue foregone per dollar's worth (world market price) of food aid may be estimated as the treasury cost required to purchase one dollar's worth (world market price) of surplus commodities less the treasury payment necessary to reduce the quantity produced by an equal amount. The net cost may be estimated as

$$(10) \qquad NC_{PC} = \frac{P_R}{P_w}(1 - C_{PC}) + T_2 - (PV)/QP_w$$

where

NC_{PC} = net cost per dollar's worth of food aid if production control is the best alternative outlet for surplus commodities;

P_R = prices received by farmers, weighted average for the commodities involved;

C_{PC} = treasury cost required to reduce the quantity produced by an amount that, valued at prices received by farmers, is worth one dollar;

T_2 = transportation cost payable by the donor country pèr dollar of food aid.

Other notation is as defined before. The price ratio (P_R/P_W) was calculated for each of the major food aid commodities. To obtain the price ratio corresponding to food aid, each of the commodity price ratios was weighted by the amount of the corresponding commodity exported under food aid programs during 1964–1966.

Net social gain and distribution

The average net social gain ASG obtained from food aid programs may be defined as the value to the recipient country of the aid in excess of the value of the food in its best alternative use less the cost of transporting the food from donor to recipient country. Hence, the average net social gain expressed as a percentage of the face value of the aid is given by

$$(11) \qquad ASG = AV - RF - (T_1 + T_2)$$

where RF is the revenue foregone as a proportion of the face value, and T_1 and T_2 are the transportation costs per dollar of food aid paid by the recipient and donor countries, respectively. AV was defined previously.

Equation (11) may be rearranged as follows:

$$(12) \qquad ASG = (AV - T_1) - (RF + T_2).$$

If the present value of repayments PV is

[15] A complete mathematical description of the development of the model may be found in [8] or obtained directly from the authors.

subtracted from each of the two terms on the right-hand side of equation (12), the result is

$$ASG = a_1 - NC_{PC} \tag{13}$$

where a_1 is the average aid component, as in (3); and NC_{PC} is the average net cost as a proportion of the face value, as in (10).

If the present value of repayments is not equal for donor and recipient countries, the latter equation yields an estimate of ASG that is different from the former. This may be the case for export on long-term dollar credit. The opportunity cost of capital in the recipient countries may differ from the opportunity cost in the donor country under equal risk because of imperfections in the international money market. Therefore, two different discount rates would be applied.

The adjustments in the social gain due to differences in the opportunity cost of capital are taken into account in the latter formula but not in the former. Hence, the latter formula is most appropriate for estimating the net social gain.

The marginal social gain MSG as a proportion of the face value of aid may be estimated as

$$MSG = a_2 - MNC_{PC} \tag{14}$$

where a_2 is marginal aid component, as in (4); and MNC_{PC} is the marginal net cost as a proportion of the face value of aid.

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Tax in Kind to Reduce Supply and Increase Income Without Government Payments and Marketing Quotas*

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Theoretically, a tax in kind can be used to reduce supply and increase net farm income. Applied through a share payment to government, private marginal costs are increased and supply is decreased. The government also has a food fund to be used for aid or similar purposes. The mechanism requires neither government payments nor compulsory market quotas to lessen supply. However, compulsory sharing is necessary to prevent "free riders." Variants of the mechanism would include a gross sales tax collected in conjunction with income taxes. The mechanism provides a policy alternative with interesting potentials in income distribution.

THIS PAPER includes a theoretical discussion of a policy mechanism that has features of supply restraint and price improvement. However, in contrast to present farm programs (which use public payments to encourage voluntary supply control) and marketing quotas (mandatory imposition of producer quotas), the mechanism can attain the same level of supply control and price improvement with neither government payments nor imposed marketing quotas. Further, at least theoretically, the method places no restraints on freedom in farmer choice and decision, and the farmer's contribution to supply control and price improvement is roughly proportional to his gain. Finally, the mechanism has the same consumer effects (i.e., levels of food prices and progressiveness of food costs relative to income) as any other program (e.g., present land retirement programs or marketing quotas).

The proposal is applicable to all agricultural commodities with price elasticities of demand less than unity and supply elasticities greater than zero. Of course, the major commodities to which supply control and price support programs have been applied over the last four decades fall in this category.

The analysis is presented to help extend the continuous farm policy debate. It is not presented as a practical program ready for "application tomorrow." However, with additional experience of farmers in market management, commodity check-offs, marketing boards, and similar devices, it is a mechanism that could have interest, acceptance, and lower public costs. It has some features that are the equivalent of monopoly selling organizations, such as the marketing boards of Australia, Canada, and New Zealand. Meyers has presented a somewhat similar example where increased costs can result in greater profits [2].

The system is one which, theoretically, might be managed either by farmers or by government. As a farmer-managed mechanism, the farm sector could hold a "food fund" under one of the variants. The implied method of obtaining this food fund could reduce domestic market supply and bolster prices and income and also allow the farm sector to appeal to humanitarian purposes (improve public relations through the betterment of the world's hungry and poor people). The food fund under this variant could be offered to populous and less developed countries at no cost if they paid transport and handling costs (and insulated the added supplies from the market to prevent price depression for the country's producers). While the system could be farmer-managed, in the discussion that follows we suppose government to serve as the implementing agency and that legislative or other means are provided to effectuate the "sharing arrangement." The program would have to apply to all major commodity producers to prevent "free riders."

The proposed mechanism is logically simple and is only a variant of a present program mechanism. Under current acreage control programs, and through the equivalent of a cash rental payment, the government "rents" the land from the farmer or landowner and devotes it to the desired use (i.e., fallow or nonproduction). The proposed mechanism is in the same framework, except that the relationship is reversed, the government now serving implicitly as "the landlord" and the farmer as "tenant." However, the government (or a "farmer mar-

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keting board") does not become the owner but receives only a share of output. In contrast to the present system wherein the government (as tenant) pays a cash rent to the farmer (as landlord), the farmer now (as tenant equivalent, but still the owner and independent decision-maker) pays a share rent to the government (as landlord equivalent). We use this terminology to indicate that the proposed mechanism is in the framework of present programs, with only an inversion of farmer and government roles and substitution of payments in kind for payments in cash. Theoretically, but also expected in practice, a sharing of the farmer's output with government (or a farmers' marketing board) should reduce supply and raise prices and income. But this could be accomplished at no cost to government. We analyze two cases: (a) where government might use its share for international food aid, with the acquisition costs of the commodities for shipment of food aid being zero (but having the effect of reducing domestic supply and raising prices and income); (b) where the government places its share in the domestic market, but total marketed supply is decreased (as compared to no program).

The first of these alternatives increases farm costs because more is produced; but since a share is withheld from the market, prices and total revenue increase proportionately more. Under the second method, total farm costs decrease; and price, total revenue, and aggregate profits to producers increase. Hence, the system has versatility and diversity, at least in its basic theory and logic and in other possible variants. In economic effect, the program could be applied to single commodities without close substitutes, to commodity groups that embrace all close substitutes or all commodities of the farm sector.

The share of product could perform another role if the system were self-managed by farmers. (Government legislation and authority would be essential to create the program, but farmers could manage it.) Most farm organizations re-require monetary dues from their members. Hence, rather than a cash payment, the product share explained later would serve as "due payments in kind" but also would serve simultaneously as the mechanism which reduces output and increases prices and income. Some farm organizations already use a "check-off" system. Typically the check-off is employed to obtain funds for product promotion and is too small to affect supply. The method explained below would be the equivalent of a check-off system, but requires a much larger share and would have objectives of raising producers' prices and incomes through its effect in restraining supply.

A similar result could be obtained through a gross sales tax. If collected from farmers as a percentage of sales price for commodities under the program, in conjunction with the federal income tax, the program not only would, theoretically, attain goals heretofore specified but also would have much lower administrative costs than any other program. (Our tax in kind would still require "policing" to guarantee that each farmer pays his "honest share" and "free riding" is prevented.) If the share rent were commuted to cash, complexities surrounding the intermediate and final nature of various agricultural products would be lessened. The government then could use the revenue so obtained to buy food for aid shipments. In another variant of the general approach, the government could withdraw all "rights" for production of agricultural commodities. Farmers would then buy these rights at a price paid per unit of output at the outset of the production season (so that capital requirements are increased during the production period). The level of the price, paid for the "right to produce," would determine the level of supply and income improvement. However, it might be more difficult to convince farmers that a "price for the right to produce" would benefit them as readily as an output share contributed to the government to lessen supply. Both systems have interesting implications in income distribution through variations in rates paid by farmers with different volumes or sizes. We analyze its effect on market revenue, output, and income distribution elsewhere [1].

Assumptions and Nature of Model

To illustrate the rationale of the proposal, we turn to a simple algebraic example and use a naive model which is hybrid in its degree of generality and numerical reference. Later we make a geometric summary. The results would be the same regardless of the algebraic relationships employed as long as we refer to commodities with price elasticities for demand of less than unity and for supply of greater than zero. The method would apply to all commodities with these characteristics. However, to maintain simplicity, we refer to a single commodity and a single agricultural resource to reflect

production and cost relationships. The numerical parameters used, to provide a degree of specificity, slightly overstate the conditions surrounding agriculture but are used for purposes of emphasis and do qualitatively describe the market economy.

We suppose the demand function:

$$P = \beta Q_d^{-2} \tag{1}$$

where the price elasticity is $-.5$, β reflects income, population, and consumer preference components of demand while P and Q_d are respectively the market price and quantity variables. Supposing n farms each with the same production function and each producing n^{-1} proportion of the total, the aggregate production of the producing sector is

$$Q_p = \alpha X^{1/2} \tag{2}$$

where Q_p is output and X is a variable resource (or a collection of variable inputs used in a given mix). Under assumptions of perfect knowledge and profit maximization objectives, the sector's total cost function is (3) and its marginal cost function is (4) where P_x is the price of inputs:[1]

$$TC = \alpha^{-2} P_x Q_p^2 \tag{3}$$

$$MC = 2\alpha^{-2} P_x Q_p \tag{4}$$

Equating marginal cost to price and setting quantity dependent, the commodity supply function is

$$Q_s = .5\alpha^2 P P_x^{-1} \tag{5}$$

In an overly simplified context of a simultaneous supply and demand period, the demand function in (1) and the supply function in (5) are equated to generate equilibrium market price and quantity, farm revenue, total costs, and net profit. So computed, the quantities reflect the situation (as denoted by the subscript o) in the absence of any policy to modify supply. Market price is expressed in (6), equilibrium output quantity in (7), total revenue in (8), total costs in (9), and net profit of the farm sector in (10):

$$P_0 = 2^{2/3}\alpha^{-4/3}\beta^{1/3}P_x^{2/3} \tag{6}$$

$$Q_0 = 2^{-1/3}\alpha^{2/3}\beta^{1/3}P_x^{-1/3} \tag{7}$$

$$TR_0 = 2^{1/3}\alpha^{2/3}\beta^{2/3}P_x^{1/3} \tag{8}$$

$$TC_0 = 2^{-2/3}\alpha^{-2/3}\beta^{2/3}P_x^{1/3} \tag{9}$$

$$\pi_0 = (2^{1/3} - 2^{-2/3})\alpha^{-2/3}\beta^{2/3}P_x^{1/3} \tag{10}$$

In the equations above and those that follow, we retain fractional forms of exponents and keep separate the numerical multipliers in order that others who wish to adapt the analysis further can minimize the arithmetic in doing so.

Implementation of the Policy

Given the price and income quantities under market equilibrium above, we now implement the policy mechanism to reduce supply and improve prices and income. To do so, the government requires a .2 share of total production (an amount of production equal to .25 proportion of the farmers' share).[2] Under these shares, the production and demand functions remaining the same, the farmers' total cost function and the aggregate supply function now become (11) and (12) respectively (the latter derived from the marginal cost function conforming with TC_0' as explained in footnote 2). The market supply, Q_s', is the farmers' share only.

$$TC_0' = 1.25^2\alpha^{-2}P_x Q_P^2 \tag{11}$$

$$Q_s' = (.5)(1.25^{-2})\alpha^2 P P_x^{-1} \tag{12}$$

Equation (11) is the total cost function of the marketed share of output. Of course, the total cost function of total output (farmers' marketed share of .8 and government's share of .2)

[1] The total cost function is derived from the production function in this manner: Inputs required as a function of output are

(a) $$X = \alpha^{-2} Q_p^2$$

and the total cost of inputs is

(b) $$TC = P_x X$$

Now, by substituting the input relationship of (a) for X in equation (b), the total cost function is expressed as equation (3).

[2] When the farmer must give a .2 share to the government (or "farmers' board"), the farm share of the production function is

(c) $$Q_p = .8\alpha X^{1/2}$$

and the input equation is no longer (a) in footnote 1, but becomes

(d) $$X = 1.25^2\alpha^{-2}Q_p^2.$$

Substituting this value of X into the cost function of (b) in footnote 1, the farm total cost function becomes (11) and the corresponding marginal cost function is

(e) $$\frac{d(TC)}{dQ_p} = 2(1.25^2)\alpha^{-2}P_x Q_p.$$

This same marginal cost function for farmers' share prevails for the situation in which the government market is .2 share.

does not change. The private marginal cost curve of the farmer is raised (to equation (e) in footnote 2, from equation (4) in the text), although the social or true marginal cost for total output is not changed. However, since farmers base their decision on their private marginal costs, the supply function then is changed from equation (5) to equation (12).

The government, which receives .2 of total output or $.25Q_s'$, ships its share as food aid to other countries that are insulated from the domestic market. With the modified supply under government sharing of output, supply in (12) and demand in (1) are now equated. A new market equilibrium is created and the corresponding commodity price, supply quantity, farm revenue, total farm costs (at the equilibrium output of Q_1) and net profits are those respectively in equations (13), (14), (15), (16), and (17):

$$(13)\qquad \begin{aligned} P_1 &= (1.25^{4/3})(2^{2/3})\alpha^{-4/3}\beta^{1/3}P_x^{2/3} \\ &= 1.25^{4/3}P_0 \end{aligned}$$

$$(14)\qquad \begin{aligned} Q_1 &= (.8^{2/3})(2^{-1/3})\alpha^{2/3}\beta^{1/3}P_x^{-1/3} \\ &= .8^{2/3}Q_0 \end{aligned}$$

$$(15)\qquad \begin{aligned} TR_1 &= (.8^{-2/3})(2^{1/3})\alpha^{-2/3}\beta^{2/3}P_x^{1/3} \\ &= .8^{-2/3}TR_0 \end{aligned}$$

$$(16)\qquad \begin{aligned} TC_1 &= (1.25^{2/3})(2^{-2/3})\alpha^{-2/3}\beta^{2/3}P_x^{1/3} \\ &= 1.25^{2/3}TC_0 \end{aligned}$$

$$(17)\qquad \begin{aligned} \pi_1 &= \left[(1.25^{2/3})(2^{1/3}) - (1.25^{2/3})(2^{-2/3})\right] \\ &\quad \cdot\alpha^{-2/3}\beta^{2/3}P_x^{1/3} = 1.25^{2/3}\pi_0 \end{aligned}$$

Individual farmers are not restrained in any manner. They can produce to their heart's content (i.e., so that profit is maximized by equating marginal cost with market price—as under the absence of a program). Yet the system results in a marked improvement in price ($P_1=1.25^{4/3}P_0$), market revenue ($TR_1=1.25^{2/3}TR_0$), and profit ($\pi_1=1.25^{2/3}\pi_0$), as market supply is reduced ($Q_1=.8^{2/3}Q_0$). Total costs increase ($TC_1=1.25^{2/3}TC_0$), since the total output (including the government's share) now is greater than the original equilibrium output, Q_o.[3] The share marketed by farmers is Q_1; but since the government receives an amount equal to .25 Q_1, total output is actually 1.25 Q_1 (with .25 Q_1 held from the market) which is larger than Q_o (i.e. total output of 1.25 $Q_1=1.25^{1/3}\,Q_o$).[4] Yet the large increase in price and total revenue, from P_o to $1.25^{4/3}\,P_o$ and TR_o to $1.25^{2/3}\,TR_o$ respectively, more than offsets increased costs and causes net profits to increase, as denoted by comparing π_1 (17) with π_o (10). Not only has the system increased price, market revenue, and net profit, but it also has provided a food fund of .25 Q_1, to use as international aid or for other humanitarian causes, at zero farm level acquisition costs. This is one of the few "have your cake and eat it too" outcomes that can be found in farm policy.

Food Aid Absent

But suppose the green revolution prevails and there are no hungry people in the world to solve the problems of domestic farmers through augmentation of foreigners' diets (or simply suppose that foreign farmers take up arms and prevent commodities from being dumped in their markets to depress price). Or suppose the domestic population has values which prevent the government (or the farmers' own marketing board) from destroying a share of food produced. The system will still work to increase aggregate farm income even with the government marketing its share.

To illustrate, suppose that the government now takes a .2 share of total output and places it on the market. Since the sharing arrangement increases farmers' private marginal costs (for their own share) it also dampens supply and improves price and income. The total cost function (relative to their .8 share) for farmers under this variant is the same as (11). Deriving marginal costs from this total cost function (see footnote 2) and adding the government's share (.2 of the total or a .25 proportion of the farmer share), the total supply function is

$$(18)\qquad Q_s'' = (1.25^{-1})(.5)\alpha^2PP_x^{-1}$$

With demand remaining as (1) and with total

[3] Total output, including the .2 share paid as rent in kind to the government and removed from the domestic market "to be shipped as food aid," is $1.25Q_1$ or $1.25^{1/3}\,Q_o$ (but farmers place only $.8^{2/3}Q_o$ on the market). While the new total output is larger than the previous output, the smaller amount marketed improves price so that even under the share restrained supply function the price effects offset the share effects on total output (but not on marketed output).

[4] The equilibrium output, Q_1, in (14) is generated from the supply function, Q_s', in (12). But Q_1 is only .8 portion of total output. The total equilibrium output is thus $Q_1+.25Q_1$ and the total output corresponding to supply function Q_s', when $.25Q_s'$ is added to denote the government share, is $Q_s'+.25Q_s'=1.25\ (.5)\ (.8^2)\alpha^2PP_x^{-1}=1.25^{-1}$ $(.5)\alpha^2PP_x^{-1}$ which in turn is the same as supply function Q_s'' (farmers output and government marketed share in (18).

market supply (farmer share plus .2 of the total for government) in (18) equated to demand, the market price, equilibrium output, market revenue, total farmer costs (for the equilibrium output), and net profit are given respectively in (19), (20), (21), (22) and (23):

$$(19)\quad \begin{aligned} P_2 &= (1.25^{2/3})(2^{2/3})\alpha^{-4/3}\beta^{1/3}P_x^{2/3} \\ &= 1.25^{2/3}P_0 \end{aligned}$$

$$(20)\quad \begin{aligned} Q_2 &= (1.25^{-1/3})(2^{-1/3})\alpha^{2/3}\beta^{1/3}P_x^{-1/3} \\ &= .8^{1/3}Q_0 \end{aligned}$$

$$(21)\quad \begin{aligned} TR_2 &= (1.25^{1/3})(2^{1/3})\alpha^{-2/3}\beta^{2/3}P_x^{1/3} \\ &= 1.25^{1/3}TR_0 \end{aligned}$$

$$(22)\quad \begin{aligned} TC_2 &= (1.25^{-2/3})(2^{-2/3})\alpha^{-2/3}\beta^{2/3}P_x^{1/3} \\ &= 1.25^{-2/3}TC_0 \end{aligned}$$

$$(23)\quad \begin{aligned} \pi_2 &= \left[(1.25^{1/3})(2^{1/3}) - (.8^{2/3})(2^{-2/3})\right] \\ &\quad \cdot\alpha^{-2/3}\beta^{2/3}P_x^{1/3} = 1.28\pi_0 \end{aligned}$$

The total revenue (21) is that forthcoming from sale of the .8 share of farmers' and .2 share of government's output. Hence, this total revenue is realized by farmers only if the government transfers its .2 share of total revenue back to farmers. The aggregate net profit in equation (23) represents gross revenue to farmers and to the government less farmers' costs of producing the equilibrium output. For the example used, aggregate net profit is 28 percent greater than it would be under absence of the program.

The government cannot return its share of revenue to farmers in proportion to their individual sales because this would cause their private marginal costs of sales value (production) to return to the level in equation (4) and the supply-dampening feature would be destroyed. Hence, in returning its share of sales to the farm sector, the government must use methods that divorce the distribution from current market shares of individual farmers. An opportunity for gain in economic and social goals prevails in this transaction. For example, part of the government's revenue might be returned to farmers (but nonproportionally to output) and the remainder distributed to low-income consumers in order to reduce the "regressive" effects of price improvement. High-income consumers then would bear the burden of increasing incomes of both low-income consumers and farmers-at-large. Under certain conditions of share magnitudes and distribution patterns, the net profit of the farm sector could be increased with (a) some improvement made in the income of all farmers but (b) a greater improvement made in the income of low-income farmers.

As compared to no program, another "eat your cake and have it too" situation arises. Farmers have higher prices, revenue, and profit than under absence of a program, because marginal costs of their own output share are higher and market supply is less. The market price, P_2 in equation (19), is greater than under no program, P_o, but is lower than the price, P_1, when the government exports its .2 share. While the government now markets its .2 share, the equilibrium market supply of Q_2 is still smaller than the original equilibrium supply, Q_o, in the absence of a program.

This formulation of the policy, when compared with the one in which the government insulates its share from the domestic market (shipping it as food aid or simply burying it), indicates lower attainment for farmers. (A program paying farmers not to produce would have lower social costs than if the government destroyed its share under their variant.) However, attainment in price and revenue improvement and supply control is greater than under no program and at no cost to the government. Farmers continue to own their resources and maintain freedom of decision (in contrast to implied mandatory marketing quotas). But, as mentioned previously, the government would need a group of "inspectors" to ensure that all farmers pay their share and that "free riding" is prevented. In other words, compulsory participation would be required but no compulsory quotas or upper bounds on production or marketings would need to be imposed.

Geometric Summary

While not all relevant quantities can be included in a simple geometric presentation, the effect of the mechanism on price, market revenue, and supply quantity is summarized in Figure 1. (A somewhat different algebraic characterization of supply and demand relationships is implied in the figure than in the equations presented previously. Also, the geometric example does not provide an explanation, through marginal costs and supply functions, of how the system works.) The commodity demand function, D, again indicates a price elasticity less than unity. Under the conditions of no program, the aggregate commodity supply function is S_o and market revenue is *Odek*. With the government (or farmers' marketing board) taking the

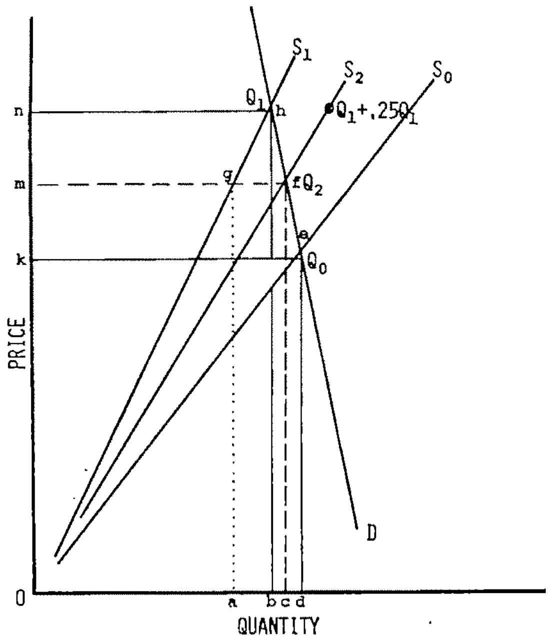

Figure 1. Geometric illustration of effects on price, supply, and market revenue

implied share of the output and withholding it from the domestic market, aggregate supply declines to S_1 and market revenue is *Obhn*, an amount greater than *Odek*. Aggregate commodity supply function S_1 denotes only the quantity marketed by farmers. It does not represent total production at each price. Total output at each price is $1.25S_1$ since farmers get a .8 share and government gets a .2 share of total production. (As explained in footnote 4, S_2 is the "total output function" when the government's share is added, although S_1 is the farmer supply function when .25 S_1 is insulated from the market as the government's share.) However, when the government places its share on the market, total domestic market supply (total production in this case) becomes S_2 and total revenue is *Ocfm*.[5] Since the product share to the government is .2, the government share of total revenue is *acfg* and the farmer share is *Oagm*. If government returns its share to farmers (but in a manner unrelated to output and marginal costs), the total revenue of farmers then becomes *Ocfm*, an amount larger than the original revenue of *Odek* because the sharing arrangement has choked back supply through its effect on marginal costs of the farmers' original share.

Figure 1 also summarizes the relative magnitudes of output under the program variants. The quantity Q_o expresses equilibrium market output. The quantity Q_1 is the .8 proportion of total output marketed by farmers when the government takes its share off the domestic market. (Total output is 1.25 Q_1, with the government removing .2 share of this from the market.) However, when the government markets its .2 share, the equilibrium total output is Q_2. Hence, $1.25Q_1$ is greater than both Q_o and Q_2. Total costs, TC_1, also are greater when the government exports its share than under "no program" or "government marketed shares."

Other Considerations

The mechanisms discussed above provide a rather unique policy instrument for reducing supply, increasing prices and income, and acquiring a food fund for international aid at zero farm costs to the government and without imposition of marketing quotas. Of course, in any actual implementation, the government would have handling and transport costs for its share exported as aid (or used to alleviate domestic hunger); but it has had these costs in all previous programs. If it marketed its share domestically, it would have related handling costs; but because of the smaller output (than under no program), these costs also would be lower and the total net revenue that could be realized by farmers would still increase.

Under real world conditions we would expect farmers to use less fertilizer and other capital inputs if a share of output were handed to the government without a proportionate sharing of costs. The extent to which output would be dampened, or the share required to restrain output and improve prices to particular levels, is unknown. But lack of quantitative knowledge has always prevailed as various policy variables were manipulated in the past. Under the policy mechanism presented, experimentation through implementation also would be required. Under actual conditions of farm supply response (which incorporates effect of uncertainty, physical, monetary, and personal restraints, and other parameters and variables), some time would be required to determine the share necessary to restrain supply to levels resulting in goals of price and income improvement.

We do not propose that this policy instru-

[5] The function of total output $(1.25S_1$ including the government share, since S_1 represents only the .8 portion marketed by farmers) is identical with the function S_2 (which denotes total output under the situation).

ment outlined is one of political acceptability to all farm groups. However, the proposition is one of logical consistency and, it is hoped, adds to the intellectual environment surrounding farm policy analyses.

Because of its theoretical nature and limitations on space, we have not pursued various other ramifications of the particular program. It is perhaps likely that even under its income improvement the mechanism would be more effective than traditional land retirement in preventing a further overcommitment of resources in agriculture over the long run. This tendency might be restrained through a higher rental rate of tax in kind for new entrants in farming. Programs of the past decade have brought much greater gains to large, high income farms than to those at the other end of the scale. A differential set of rental shares among farmers could be used to benefit all farmers, but to bring a relatively larger gain to those of low-income strata. It is possible that a program of this type would have a somewhat greater social cost in underemployment of resources than existing voluntary land retirement programs (where farmers with low comparative advantage participate and those with high advantage remain out). However, it is unlikely that social costs in this context would be greater than for a program of compulsory marketing quotas where a restraint is placed on all farmers irrespective of their efficiency and comparative advantage.

This article concerns itself with the technical aspects of a policy mechanism. Other analyses can examine the long-run, social cost, and distributive characteristics of its potential variants. A policy in the general framework then might be outlined to have acceptance to farmers, improve equity, lessen competition for treasury outlays, and attain other relevant goals.

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Stochastic Programming, Utility, and Sequential Decision Problems in Farm Management*

Allan N. Rae

This paper presents a further development of discrete stochastic programming, viewed within the context of Bayesian decision theory. Some probability models and information structures (with and without additional information) are discussed, followed by an indication of how the stochastic programming matrix may be set up to reflect the various information structures. Some expected utility theories are then reviewed, and their usefulness in allowing the specification of a wide variety of objective functions for the stochastic programming model is illustrated. Lastly, a method is presented for determining the money value of additional information, additional resources, and the expected cost of uncertainty.

Farm management typically requires that decisions be made at times when the outcomes or implications of those decisions will not be known with certainty by the farmer. Hence, many problems in farm management can be conveniently stated in terms of decision theory as they involve the specification of possible actions, states of nature, the probabilities of the states of nature, consequences of the actions given the various states of nature, and a utility function to be maximized.[1] The farmer might also have access to some additional information, such as weather or price forecasts.

Many farm management problems differ from the "conventional" specification of decision-theoretic problems in that the predefinition of all possible acts may be impossible; for example, the number of acts may be infinitely large, or acts may have to be chosen from within the confines of a restraint set. As such problems map readily into a mathematical programming framework, however, this paper will further develop a recently presented stochastic programming model [6] so as to make the method applicable to a wider range of decision problems encountered in farm management research.

Probability Models

The actual outcome of the decision-maker's action in a stochastic decision problem will depend upon the choice, made by "nature," of an event (state of nature) from the complete set of such events. It will be convenient to think of nature's choice as being the outcome of a random experiment. In a sequential decision problem there will exist a whole series of actions, each followed by the performance of such a random experiment. Hence, let R be a probability model that represents the t-stage random experiment mathematically. R will be considered to be built up from, or decomposable into, separate random experiments

$$R_{n_t t}, \qquad t = 1, \cdots, T$$
$$n_t = 1, \cdots, N_t$$

where n_t (the number of possible experiments within each stage) may vary with t, and the random experiment to be performed at any stage may depend upon the outcomes of random experiments performed in previous stages. Let the mathematical models of $R_{n_t t}$ have the event sets

$$(1) \qquad \xi_{n_t t} = \{e_{j,n_t t}; j = 1, \cdots, s\}.$$

The subjective probabilities[2] of the simple events of $\xi_{n_t t}$ will be given by the set

$$(2) \qquad P_{n_t t} = \{p_{j,n_t t}; j = 1, \cdots, s\}.$$

It is possible that the actual values of the probabilities may change from one model to another, or with n_t.[3] Also, no restriction is implied by assuming that all the experiments $R_{n_t t}$ have the same (sufficiently large) number, s, of outcomes, since if the kth event, e_k, is impossible in some $R_{n_t t}$ its probability is zero, or $p_{k,n_t t} = 0$.

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[1] See [4, 12, 16, 19] for expositions of modern decision theory.

[2] Since the model is intended to maximize the expected utility of the decision-maker, the probabilities of the simple events must also be those of the decision-maker, which indicate his relative strength of belief as to the outcome of nature.

[3] In other words, the probabilities may be conditional on the outcome of the random experiments of previous stages.

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Hence a mathematical model R can be constructed to provide a representation of the random experiment by forming the direct product of all probability models $R_{n_t t}$. Thus the mutually exclusive and collectively exhaustive set of all possible outcomes of R will be derived[4] (along with their associated probabilities of occurrence) and will be indexed by r, $r = 1, \cdots, k$.

In some farm management problems there may exist the possibility that the decision-maker will obtain additional information about nature's likely choice from $\xi_{n_t t}$ before making a decision. A modified probability model is presented below in which it is assumed that forecasting experiments may be performed prior to nature revealing the outcome of the random experiments.[5] Let W be a probability model which forms a mathematical representation of the t-stage forecasting experiment. W, as was R, will be considered to be built up from separate forecasting experiments represented mathematically by

$$W_{m_t t}, \qquad t = 1, \cdots, T$$
$$m_t = 1, \cdots, M_t.$$

Let the models $W_{m_t t}$ have the event sets

$$(3) \qquad F_{m_t t} = \{f_{k, m_t t};\ k = 1, \cdots, s\}$$

where each forecast event implies a particular probability distribution of the states of nature. Since there exist a total of s possible outcomes of nature in any probability model $R_{n_t t}$, it will be assumed that any of these outcomes could be predicted by the forecasting experiment. The number of possible events in $F_{m_t t}$ will therefore also equal s.

Now, given the (prior) probabilities of the simple events in $\xi_{n_t t}$ and the probabilities of the forecasts conditional on the simple events, Bayes' theorem may be applied to derive the posterior probabilities of the simple events conditional on the forecasts

$$(4) \qquad P'_{n_t t} = \{p'_{j, n_t t};\ j = 1, \cdots, s\}$$

and the unconditional probabilities of the forecasts

$$(5) \qquad Q_{m_t t} = \{q_{k, m_t t};\ k = 1, \cdots, s\}.$$

Thus the mathematical model of the now Bayesian probability model will be given by the direct product $R' \times W$, $R'W$.

Information Structures and Matrix Construction

Decision problems may be characterized by their information structures, that is, the pattern of information receipts in relation to the decision dates. Several information structures can be handled by the stochastic programming model, and the design of the matrix for different structures is the main topic of this section.

Possible information structures may be classified as follows: At the beginning of stage t of the decision process, the outcomes of stages $t-i$, $t-i-1$, $\cdots$, are known with certainty by the decision-maker but the outcomes of stages $t-i+1$, $t-i+2$, $\cdots$, are known only in the form of probability distributions of outcomes conditional on the known outcomes of past time periods. Hence, if $i=0$, the decision-maker has complete knowledge of past and present; if $i=1$, he has complete knowledge of the past; and if $i>1$, he has incomplete knowledge of the past. As an example of the last structure, should $i=2$ the actual outcome of stage $t-2$ but *not* $t-1$ is known at the beginning of the tth stage. Thus the receipt of information is lagged by one time period.

The above information structures may be augmented where the decision-maker can receive a forecast (or perform some other experiment) to provide additional information on the actual outcome of nature in past stages or the likely outcome of nature in present and/or future stages.

Matrix construction in the case where $i=0$ has been discussed elsewhere [6], so attention here will be on the two information structures given when $i=1$, and when $i=1$ and a forecast of stage $t-i$, where $i=0$, is available to the decision-maker. Matrix construction for all other possible information structures should be clear after study of these examples. Concern will be mainly with the restraints $Ax \leq b$; the last restraint group in each example will simply

[4] Since no mention of possible acts is made in the probability model, the event probabilities are taken to be independent of the acts. Where this assumption is unacceptable, it may be possible to formulate the programming problem so that its solution would comprise several "runs," each run allowing only a certain subset of acts and hence the appropriate event probabilities.

[5] Here, interest lies mainly in preposterior analyses, in which the value of the experiments can be determined *before* they are undertaken. Thus the decision-maker has the opportunity to determine whether or not it will be profitable for him to undertake such experimentation or which of a number of alternative experiments is the most profitable.

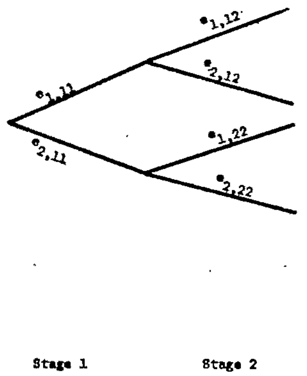

Figure 1. A two-stage probability model

collect net payoffs for each possible state of nature, which will then transfer the value to some appropriate objective function.[6] Although each information structure is treated separately, combinations of the various structures can be built into the matrix and may be encountered in practical sequential decision problems.

Complete knowledge of the past

The two-stage probability model of Figure 1 will be used to illustrate the case. The linear programming matrix would be constructed as in (6). Thus the vectors of activity levels x_{11}, x_{12} and x_{22} form a strategy. At the beginning of stage one the (permanently feasible) vector x_{11} is initiated. At the beginning of the second stage the decision rule would be: "Follow x_{12} if $e_{1,11}$ occurred in stage one, but follow x_{22} if $e_{2,11}$ occurred in the first stage."

(6) $\qquad$ maximize $E(u) = f\{w\}$

subject to

$$
\begin{array}{lllll}
A_{1,11}x_{11} & & & & \le b_{1,11} \\
 & A_{1,12}x_{12} & & & \le b_{1,12} \\
 & A_{2,12}x_{12} & & & \le b_{2,12} \\
A_{2,11}x_{11} & & & & \le b_{2,11} \\
 & & A_{1,22}x_{22} & & \le b_{1,22} \\
 & & A_{2,22}x_{22} & & \le b_{2,22} \\
-Ix_{11}^* & Ix_{12}^* & & & \le 0 \\
-Ix_{11}^* & & Ix_{22}^* & & \le 0 \\
-C_{11}x_{11} & -C_{12}x_{12} & -C_{22}x_{22} & +\{w\} & = 0
\end{array}
$$

[6] The manner in which such payoff values may be converted into an appropriate utility measure will be discussed in later sections.

where $E(u)$ is expected utility;

$A_{1,11}x_{11} \le b_{1,11}$ and $A_{2,11}x_{11} \le b_{2,11}$ are the restraints should event $e_{1,11}$ or $e_{2,11}$, respectively, occur in the first stage;

$A_{1,12}x_{12} \le b_{1,12}$ and $A_{2,12}x_{12} \le b_{2,12}$ are the restraints should event $e_{1,12}$ or $e_{2,12}$, respectively, occur in the second stage;

$A_{1,22}x_{22} \le b_{1,22}$ and $A_{2,22}x_{22} \le b_{2,22}$ are the restraints should event $e_{1,22}$ or $e_{2,22}$, respectively, occur in the second stage;

$\{w\}$ is some set of activities that transforms payoffs into the appropriate utility levels;

x_{11}^* is a vector that includes only those activities that are continued into the second stage—likewise x_{12}^* and x_{22}^* include only those second-stage activities that were initiated in the previous stage; and

C is a matrix of payoff coefficients due to the activities x, where each row of the matrix contains the payoffs given each outcome of R.

Forecasts as additional information

This example will serve to illustrate matrix construction for those problems in which a forecast is available to the decision-maker. For this particular model the decision-maker, at the beginning of stage t, knows the outcomes of all previous stages and in addition receives a forecast that provides additional information on the likely outcome of stage t.[7] This situation will be illustrated with the two-stage probability model[8] of Figure 2. At the beginning of stage one either forecast $f_{1,11}$ or $f_{2,11}$ might be received. Unless the forecasts are perfect, either may be followed by one of two outcomes. For

[7] In this particular model a forecast of the outcome of stage t is received at the beginning of stage t (for example, a forecast of weather to be experienced during stage t). Other possibilities exist, though, such as successively more accurate forecasts of the outcome of stage $t+k$ being received at the beginning of stages $t, t+1, \cdots, t+k$ (for example, forecasts of crop prices received throughout the growing season). Computation of probabilities through Bayes' theorem would then be a sequential process, with the posterior probabilities of one random experiment becoming the prior probabilities of the next.

[8] All probabilities in this model would be calculated by application of Bayes' theorem. For example, $q_{1,11}$ and $q_{2,11}$ would be the unconditional probabilities of the forecast events $f_{1,11}$ and $f_{2,11}$ respectively, and $p_1'{}_{,11}$ and $p_2'{}_{,11}$ would be the posterior probabilities of events $e_{1,11}$ and $e_{2,11}$ respectively, conditional on the receipt of $f_{1,11}$.

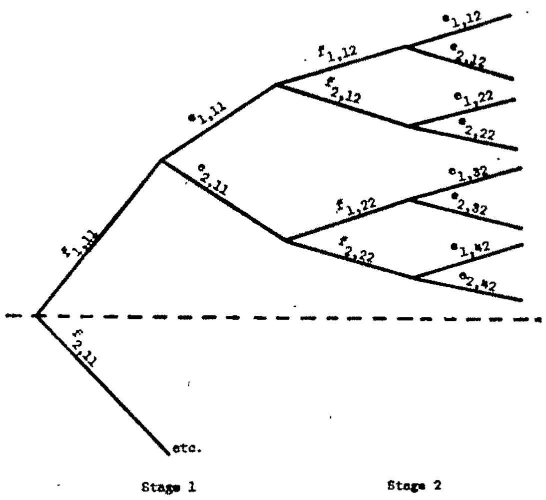

Figure 2. A two-stage probability model with additional information

example, following the receipt of $f_{1,11}$ the decision-maker (at the *end* of stage one) may have observed either $e_{1,11}$ or $e_{2,11}$. Since the stage one decision rule will consist of two actions, one for each possible forecast, the decision problem may be decomposed into two separate stochastic programming problems. One will assume that forecast $f_{1,11}$ is received, and the other will assume the receipt of $f_{2,11}$. The matrix structure of the first subproblem is illustrated in (7).[9]

where $A_{2,11}$ and $b_{2,11}$, for example, is the matrix of activity resource requirements and the vector of resource supplies, respectively, appropriate to the event $e_{2,11}$.

The activity vectors $x_{k,m_t t}$ may be interpreted as follows: "If the forecast event $f_{k,m_t t}$ is received, then operate activities at the levels indicated by the vector $x_{k,m_t t}$." For example, if forecast $f_{1,11}$ was received at the beginning of stage one, activities would be initiated at the levels given by $x_{1,11}$.

Utility Models

The solution of stochastic programming problems requires that the decision-maker can express preferences between probability distributions of outcomes or, the same thing, between strategies that give rise to the probability distributions. Various theories of utility have been proposed as models of rational behavior, and each consists of a number of axioms of "rational behavior" which, if satisfied by the decision-maker, would guarantee the existence of a

[9] If the expected utility of each optimal strategy (from the two subproblems) is $E(u_1^*)$ and $E(u_2^*)$, then the expected utility of the Bayesian strategy will be given by $E(\bar{u})$, where

$$E(\bar{u}) = q_{1,11}E(u_1^*) + q_{2,11}E(u_2^*).$$

$$\text{(7)} \qquad \text{maximize } E(u_1) = f\{w_1\}$$

subject to

$$\begin{array}{cccccccc}
A_{1,11}x_{1,11} & & & & & & \le & b_{1,11} \\
 & A_{1,12}x_{1,12} & & & & & \le & b_{1,12} \\
 & A_{2,12}x_{1,12} & & & & & \le & b_{2,12} \\
 & & A_{1,22}x_{2,12} & & & & \le & b_{1,22} \\
 & & A_{2,22}x_{2,12} & & & & \le & b_{2,22} \\
A_{2,11}x_{1,11} & & & & & & \le & b_{2,11} \\
 & & & A_{1,32}x_{1,22} & & & \le & b_{1,32} \\
 & & & A_{2,32}x_{1,22} & & & \le & b_{2,32} \\
 & & & & A_{1,42}x_{2,22} & & \le & b_{1,42} \\
 & & & & A_{2,42}x_{2,22} & & \le & b_{2,42} \\
-Ix^*_{1,11} & Ix^*_{1,12} & & & & & \le & 0 \\
-Ix^*_{1,11} & & Ix^*_{2,12} & & & & \le & 0 \\
-Ix^*_{1,11} & & & Ix^*_{1,22} & & & \le & 0 \\
-Ix^*_{1,11} & & & & Ix^*_{2,22} & & \le & 0 \\
-C_{1,11}x_{1,11} & -C_{1,12}x_{1,12} & -C_{2,12}x_{2,12} & -C_{1,22}x_{1,22} & -C_{2,22}x_{2,22} & +\{w_1\} & = & 0
\end{array}$$

utility function for that individual.[10] In stochastic programming the strategies will possess probability distributions of one-dimensional or multidimensional outcomes, and expected utility theory will be found useful in expressing preferences between such strategies and allowing the decision-maker's preferences to be transformed into a numerical function which may then serve as the objective function of the stochastic programming model.[11]

The problem of utility measurement over time can be approached in either one of two ways. First, the additive utility approach requires the specification of future utility functions u_t, $t=1, \cdots, T$, and the aggregate utility value of any stream of payoffs is computed as the sum of (discounted) utility values received in each future time period [25]. Second, the components of the payoff stream may be discounted and summed to a present value and *then* converted to a utility value [22].

The second approach is adopted here since only one utility function is required to be estimated, that which relates utility to payoff present values. The first approach is perfectly compatible with the stochastic programming model but is believed to be difficult to implement in practice because of the necessity of having to estimate future utility functions.[12]

The discount factor used in the calculation of present values should be that specified by the decision-maker so as to express his personal preference, or "impatience," for present over future returns. "Eventual" impatience may be handled by discounting only for periods sufficiently far away in the future, so discounting may not occur in the near future [8]. Of course, if the decision-maker has no time preferences or if the planning period is of a sufficiently short duration, the future will neither be discounted nor "overcounted" with respect to the present. Lexicographic utilities could be useful where decision-makers are overwhelmingly concerned with immediate returns or where the nature of the "flow" of returns over the planning period is of importance.

The one-dimensional expected utility model

Expected utility theory implies that a number (or utility) can be assigned to each of the r, $r=1, \cdots, k$, possible outcomes of a strategy, and that the expected utility of a strategy can be computed as a weighted sum of such utilities, the weights being probabilities $p^{(r)}$, $r=1, \cdots, k$. Bernoulli [2] and, later, von Neumann and Morgenstern [37] were the first to state axioms of ordering, independence, and continuity (or the Archimedean axiom) which implied the expected utility theorem. Since then different authors have developed different sets of axioms which are roughly equivalent.[13]

As guidelines of rational behavior, some of these axioms have been subject to criticism, and modified sets of axioms have been proposed as more suitable for certain preference structures. Some of these alternative models, such as lexicographic utilities, will be referred to later.

A general formulation of the one-dimensional objective function.—The approach adopted to incorporate the decision-maker's utility function into the programming model is to approximate the function with a number of linear segments. A utility function that is convex from above implies strict risk aversion on the part of the decision-maker, and by approximating such a function with a number of linear segments the convexity assumption of linear programming holds good. Should the utility function be nonconvex, it may still be approximated with a number of linear segments and incorporated into a linear programming model, provided that the analyst has access to a linear programming algorithm that contains a separable programming subroutine [18, ch. 4]. This technique, however, is recommended only for "slightly concave" separable functions; if the utility function is "highly concave," the decision-maker should be willing to settle for a local rather than a global optimal solution.

The objective function of the stochastic linear (or separable) programming problem may be set up as in (8). In this example, monetary payoffs are discounted and summed to a present value before being converted to a utility measure.

$$\text{(8)} \qquad \text{maximize } E(u) = p'u$$

subject to

$$[-c_t^{(r)}x_t + (1+\eta)^t w_{at}^{(r)} - (1+\eta)^t w_{bt}^{(r)} = 0; \quad r = 1, \cdots, k]; \qquad t = 1, \cdots, T$$

$$-\sum_{t=1}^{T} w_{at}^{(r)} + \sum_{t=1}^{T} w_{bt}^{(r)} + w^{(r)}I \leq 0;$$

[10] For reviews of utility theory, see [9, 14].

[11] The following expected utility theories are taken from [14, pp. 354–360].

[12] Not even at the University of New England have we been successful in estimating farmers' *future* utility functions!

[13] See, for example, [4, ch. 4; 26, ch. 2].

$$r = 1, \cdots, k$$
$$-\delta' w^{(r)} + u^{(r)} \leq 0$$
$$x_t, w_{at}, w_{bt}, w^{(r)}, u \geq 0$$
$$w_{at} \cdot w_{bt} = 0;$$
$$t = 1, \cdots, T$$

where

$E(u)$ is expected utility;

p is a vector of probabilities $p^{(r)}$, $r = 1, \cdots, k$;

u is a vector of utilities $u^{(r)}$, $r = 1, \cdots, k$;

x_t is a vector of activities which could be operated in stage t of the decision process, $t = 1, \cdots, T$;

$c_t^{(r)}$ is a vector of payoff coefficients given the occurrence of the rth nature state in the tth stage;

η is the decision-maker's time preference discount rate;

w_{at} is a vector of positive payoffs $w_{at}^{(r)}$, $r = 1, \cdots, k$, of the tth stage;

w_{bt} is a vector of negative payoffs $w_{bt}^{(r)}$, $r = 1, \cdots, k$, of the tth stage; and

$w^{(r)}$ is a vector of intermediate activities which transforms the payoff present value given the rth nature state to a utility value by means of the vector of coefficients δ.

The final (nonlinear) restraint in (8) is redundant, since it will be automatically satisfied by the normal linear (or separable) programming algorithm.

Expected loss as a measure of risk.—Loss can be defined as $\min(C, 0)$ where C is the net payoff, given some state of nature. Thus when $C \geq 0$,

$$\text{(9)} \quad \begin{aligned} \text{loss} &= -\min(C, 0) = 0, \quad \text{but when } C < 0 \\ \text{loss} &= -\min(-C, 0) = C. \end{aligned}$$

If the decision-maker maximizes the expected value of some utility function and chooses among alternatives solely on the basis of expected return and expected loss, the expected utility function will be of the form

$$\text{(10a)} \quad E(u) = aE(C) - bE[-\min(C, 0)]$$

where a and b are constants.

An objective function of the stochastic programming model corresponding to the utility function of (10a) could be set up as in (11). Here, as in all later examples, a zero discount rate is assumed. Should discounting be necessary, however, the formulation of the previous objective function should indicate the required modifications to the examples.

$$\text{(11)} \quad \text{maximize} \quad E(u) = p'w_a - \phi p'w_b$$

subject to

$$-\sum_{t=1}^{T} c_t^{(r)} x_t + w_a^{(r)} - w_b^{(r)} = 0;$$
$$r = 1, \cdots, k$$
$$x_t, w_a, w_b \geq 0$$
$$w_a \cdot w_b = 0$$

where

ϕ is a "risk-aversion" parameter;

w_a is a vector of positive payoffs $w_a^{(r)}$, $r = 1, \cdots, k$;

w_b is a vector of negative payoffs $w_b^{(r)}$, $r = 1, \cdots, k$; and other variables and coefficients are as earlier defined.

The last (nonlinear) restraint in (11) will always be satisfied by linear programming, provided that $\phi \geq 1$.

By setting $\phi = 1$, the above objective function represents a *linear* utility function. Should $\phi = 2$, however, the objective may be written as in (12).

$$\text{(12)} \quad \begin{aligned} \text{maximize } E(u) &= p'w_a - 2p'w_b \\ &= p'(w_a - w_b) - p'w_b \\ &= E(\text{payoff}) - E(\text{loss}). \end{aligned}$$

Hence a comparison with the expected utility function of (10a) indicates that $\phi = 2$ implies $a = b = 1$. Assuming $a = 1$ always, the value of b (in the expected utility function) will always be one less than the value of ϕ in the programming objective. Obviously, a locus of all efficient expected payoff-expected loss pairs could be derived by parametrically varying ϕ.

The utility function based on expected payoff and expected loss could be modified by measuring loss below some payoff level d, rather than zero. Then, the right-hand-side value of zero in the first restraint of (11) would be replaced with the negative of d. An example of such an objective function will be illustrated in a later section, where d will be the satisficing level of some utility factor in a multidimensional function.

With a little matrix manipulation, it would be possible to minimize expected loss, where loss is measured below *expected payoff*, subject to expected payoff being at least as great as some predefined value which could be varied parametrically. This would give rise to the

"linear-counterpart" of an expected payoff-semivariance frontier.[14]

In an earlier section it was noted that neither approach to utility maximization over time took account of the *pattern* of receipts over time. Now, should the nature of the "flow" of receipts be of importance to the decision-maker, the expected loss objective function of (11) could be modified by introducing new rows to the matrix that would collect payoffs for each time period separately. Thus a different weighting, ϕ_t, could be assigned to expected loss in any time period t, $t=1, \cdots, T$. Should the decision-maker wish to avoid large losses over the initial stages of the planning period, the corresponding values of ϕ_t could be given a higher value than the ϕ_t appropriate to the later stages. Again, by varying the values of ϕ_t, $t=1, \cdots, T$, a whole series of solutions could be obtained. The distributions of payoff streams of each solution may then be isolated so as to guide the decision-maker in his final, subjective, choice of strategy.[15]

A note on stochastic quadratic programming and *E-V* analysis.—The discrete stochastic programming problem may be formulated as one of quadratic risk programming, since all variability in the programming coefficients is eventually reflected in the objective function [6, p. 75]. In this way the complete E-V boundary can be generated and the strategy that maximizes expected utility can be located.[16] The analysis need not be restricted to quadratic utility functions; utility functions of higher order than the second may be employed, provided that they are subject to a Taylor's series approximation so that expected utility is a function of only the mean and variance of the distribution of outcomes.

One advantage of the quadratic programming approach is that a complete E-V boundary would be generated, and if a subjective choice can be made amongst all efficient strategies the need for empirical estimation of the decision-maker's utility function will be obviated. A disadvantage, however, is that the stochastic programming model will generally be very large when specified as a linear program; the quadratic programming matrix would be approximately twice as large and computational problems might be encountered.

The multidimensional expected utility model

Should the decision-maker's preferences be influenced by a number of factors, multidimensional utility functions [11] will be required to characterize the relationship between the different factors. The utility derived by the decision-maker from the operation of a strategy might be a function of both net income and terminal assets, for example, rather than just net income alone. Now, should the decision-maker be able to specify trade-off relations between all arguments of the multidimensional utility function, indicating how much the utility of one factor must be increased to offset a decrease in the utility of another factor, then utility is effectively one-dimensional and the expected utility theorem and its axioms remain applicable on the addition of certain additivity and independence assumptions. If such trade-offs cannot be specified—for example, one factor may be overwhelmingly more important than another—then lexicographic utilities become appropriate.

Additive utilities and the independence assumption.—Let $\Gamma=\{\gamma_j\}$ be the set of all feasible solutions to the stochastic programming problem, where each is characterized by a probability distribution of outcomes defined on a set of consequences Π. In the multidimensional case, Π will be the Cartesian product $\Pi_1 \times \Pi_2 \times \cdots \times \Pi_n$ where Π_i, $i=1, \cdots, n$, is the set of all possible levels of the ith payoff factor. Also, Γ_i will be interpreted as the set of all probability distributions of the ith payoff

[14] It would also be possible to reformulate the objective so as to minimize the expected absolute deviation, again measured about expected payoff, where expected absolute deviation would be given by $[p'(w_a+w_b)]$. Thus the "linear counterpart" of an expected payoff-variance frontier could be derived.

[15] Utility functions based on either expected loss or expected absolute deviation consist of two linear segments, and Markowitz criticizes their use on the basis of these segments, especially that over the region $C \leq 0$ [28, pp. 287–297]. His argument is that choices are made among alternatives with negative payoffs on the basis of expected return only, and a resulting strategy might chance a substantial monetary loss when a more conservative strategy with a slightly lower expected return could have been chosen. Be that as it may, these functions are felt to be an improvement over some commonly used; for example, they provide a better approximation to a risk-averse utility function than do linear functions.

[16] Some controversy exists in the literature as to the usefulness of quadratic utility since such a function implies that risk aversion will increase rather than decrease with increasing wealth [30, 35]. This criticism is not seen to be relevant here, however, since the quadratic utility function refers to annual money gains and losses about some given wealth level [1, sections 4.2.1 and 4.2.2].

factor, so given any strategy γ_j in Γ, γ_{ij} in Γ_i may be identified as the marginal distribution of strategy γ_j on Π_i. Now, the theory of additive expected utility says that a utility can be attached to each γ_{ij} in Γ_i, $i=1, \cdots, n$, so that the expected utility of strategy γ_j can be computed as in (13).

$$u(\gamma_j) = \sum_{i=1}^{n} u_i(\gamma_{ij}). \tag{13}$$

That is, the expected utility of any strategy can be found by simply summing the expected utilities of each factor [12, ch. 9].

For condition (13) to be true, it has been shown that an independence axiom must be applicable in addition to those mentioned in relation to the one-dimensional expected utility model [14, pp. 358–359]. The effect of this assumption is to allow preferences to be formed among strategies on the basis of their marginal distributions. It is a simplifying assumption in that it rules out the possibility of *interaction* among factors and is analogous to an analysis of variance assumption that only first-order effects will be significant, thus ruling out possible cross-effects between factors.[17]

Multidimensional objective functions.—Any of the one-dimensional utility functions may be used to measure the utility of the payoff factors i, $i=1, \cdots, n$. Only one example of a multidimensional objective function will be presented, in which each utility function u_i expresses a nonlinear relation between utility and the level of the ith factor. This objective function is illustrated in (14). Of course, the u_i functions may be either convex or nonconvex, and in practice one might perhaps find the u_i to contain linear, convex, and nonconvex functions. Also, if discounting of payoffs is considered necessary, the objective would be set up similarly to (8) except that time preference discount rates η_i, $i=1, \cdots, n$, would have to be estimated for each payoff factor.

$$\text{maximize } E(u) = \sum_{i=1}^{n} \alpha_i(p'u_i) \tag{14}$$

subject to

$$\begin{array}{llll}
-\sum_{t=1}^{T} c_{1t}^{(r)}x_t + w_1^{(r)}I & & & \leq 0; \\
& & & r=1, \cdots, k \\
& -\delta_1' w_1^{(r)} + u_1^{(r)} & & \leq 0 \\
\vdots & & \ddots & \vdots \\
-\sum_{t=1}^{T} c_{nt}^{(r)}x_t & & + w_n^{(r)}I & \leq 0 \\
& & -\delta_n' w_n^{(r)} + u_n^{(r)} & \leq 0 \\
& & x_t, w_i^{(r)}, \quad u_i & \geq 0
\end{array}$$

where

- α_i, $i=1, \cdots, n$, are weights representing the trade-off between factors;[18]
- u_i, $i=1, \cdots, n$, are vectors of utility values $u_i^{(r)}$, $r=1, \cdots, k$;
- $c_{it}^{(r)}$, $r=1, \cdots, k$, are vectors of payoff coefficients of the ith factor, $i=1, \cdots, n$ in the tth time period, $t=1, \cdots, T$;
- $w_i^{(r)}$, $r=1, \cdots, k$, are vectors of intermediate activities which transform the payoff distribution of the ith factor, $i=1, \cdots, n$, to a utility distribution u_i, $i = 1, \cdots, n$, by means of the vectors of coefficients δ_i, and other variables and coefficients may be interpreted as before.

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[17] Where the independence assumption is unsatisfactory, it may be possible to specify the function in quadratic form as

$$u(\gamma_j) = \sum_{i=1}^{n} u_i(\gamma_{ij}) + \phi_{ik} \sum_{i=1}^{n} \sum_{k=1}^{n} u_i(\gamma_{ij})u_k(\gamma_{kj})$$

where $i=k$ is permissible. Thus the stochastic linear programming model would be converted to one of quadratic programming. For a method of estimating such "quasi-separable" utility functions, see [24].

[18] Although much has been written about the problem of determining weighting coefficients in multidimensional utility functions [10, 13], the view taken here is that there is no real need for an a priori determination of the weights. Instead, the versatility of parametric programming may be utilized to obtain solutions for a whole series of weight combinations. Then by allowing the decision-maker to make a subjective choice among solutions, the true weights will be revealed. A sensible routine would probably involve the specification of a fairly coarse "grid" of possible weight combinations at first; the decision-maker's preferences among the strategies so obtained could give some indication of the true weights, so that successively finer grids could then be located and employed. In this way, the solutions would gradually reveal the decision-maker's subjective system of factor weights.

Multidimensional functions and satisficing behavior.—The multidimensional utility function is also applicable where decision-makers exhibit satisficing rather than optimizing behavior [7]. The decision-maker in this case might express preferences among strategies in accord with "how near," in some sense, the factor levels given by the strategies come to prespecified levels of the factors. Such an objective function can be constructed by specifying the utility functions u_i according to the expected loss criteria; that is,

$$u_i = a_iC_i - b_i[-\min(C_i - d_i, 0)], \quad i = 1, \cdots, n \tag{10b}$$

where

$a_i=0$ and d_i is the satisficing level of the ith factor, $i=1, \cdots, n$.

The objective function of the stochastic programming problem could be set up to minimize the sum of the expected values of the appropriately weighted deviations below the satisficing levels of the factors,[19] as in (15).

$$\text{maximize } E(u) = -\sum_{i=1}^{n} \alpha_i(p'w_{ib}) \tag{15}$$

subject to

$$\begin{array}{llll}
-\sum_{t=1}^{T} c_{1t}^{(r)}x_t + w_{1a}^{(r)} - w_{1b}^{(r)} & & = -d_1^{(r)}; & r = 1, \cdots, k \\
-\sum_{t=1}^{T} c_{2t}^{(r)}x_t & + w_{2a}^{(r)} - w_{2b}^{(r)} & = -d_2^{(r)} & \\
\vdots & \ddots & \vdots & \\
-\sum_{t=1}^{T} c_{nt}^{(r)}x_t & \quad + w_{na}^{(r)} - w_{nb}^{(r)} & = -d_n^{(r)} & \\
 & x_t, w_{ia}, w_{ib} \geq 0 & & \\
 & w_{ia} \cdot w_{ib} = 0; & & i = 1, \cdots, n
\end{array}$$

where

d_i is the satisficing level of the ith factor, $i=1, \cdots, n$;

w_{ia} is a vector of elements $w_{ia}^{(r)}$, $r=1, \cdots, k$, which measure the extent to which the ith factor is "oversupplied" in the rth environment;

w_{ib} is a vector of elements $w_{ib}^{(r)}$, $r=1, \cdots, k$, which measure the extent to which the ith factor is "under-supplied" in the rth environment; and all other variables and coefficients are as previously defined.

The lexicographic expected utility model

The Archimedean axiom limits utility spaces to one dimension, or the real numbers. While this axiom is acceptable to decision-makers with only a single goal, or to those with multiple goals who have established acceptable trade-off relations between them, it will be unacceptable in situations where substitution of achievement between goals is not possible. To cover such possibilities, the theory of utility has been generalized by either weakening or omitting the Archimedean assumption [5, 21, 32]. Preferences are not then ranked according to single-valued expected utilities, but rather according to lexicographically ordered *vectors* of expected utility values.

The lexicographic expected utility theory [14, pp. 349–350 and 358] states that a utility $u_i(\gamma_{ij})$ can be attached to each γ_{ij} in Γ_i, $i=1, \cdots, n$, so that if γ_1 and γ_2 are two strategies in Γ with marginal distributions γ_{i1} and γ_{i2} respectively on the Π_i, $i=1, \cdots, n$, then γ_1 will not be preferred to γ_2 if and only if condition (16) is true.

$$[u_1(\gamma_{11}), u_2(\gamma_{21}), \cdots, u_n(\gamma_{n1})] \overset{L}{\leq} [u_1(\gamma_{12}), u_2(\gamma_{22}), \cdots, u_n(\gamma_{n2})]. \tag{16}$$

[19] This multidimensional objective function may be thought of as a stochastic formulation of the goal programming models first described by Charnes and Cooper [3, pp. 215–221] and developed by Ijiri [23, chs. 2–4]. It should perhaps be mentioned that the specification of some goals might involve the minimization of the deviation *above* the goal (e.g., the amount of labor hired).

The lexicographic order $\overset{L}{\leq}$ may be interpreted as meaning that γ_1 will not be preferred to γ_2 if and only if $u_1(\gamma_{11}) < u_1(\gamma_{12})$, or $u_1(\gamma_{11}) = u_1(\gamma_{12})$ and $u_2(\gamma_{21}) < u_2(\gamma_{22})$, or $\cdots$ or $u_i(\gamma_{i1}) = u_i(\gamma_{i2})$ for all $i < n$ and $u_n(\gamma_{n1}) \leq u_n(\gamma_{n2})$.

Lexicographic objective functions.—All the comments on multidimensional objective functions remain applicable to lexicographic functions with the one exception that the trade-off weights α_i are not measurable. Given the i factors and their utility functions u_i, $i = 1, \cdots, n$, the lexicographic objective could be set up as in (14), for example, but only utility values for the first factor would have a positive valuation in the objective.[20] Having maximized the expected utility of the first factor, the solution should be examined for alternative optimal solutions.[21] If none exists, the solution obtained will be optimal in terms of the lexicographic ordering (16). If alternative optimal solutions are found to exist, the value of expected utility for all other factors, that is, $u_2(\gamma_{2j}{}^*)$, $u_3(\gamma_{3j}{}^*)$, $\cdots$, etc., would need to be computed from each alternative optimal solution (where the asterisk superscript denotes that the jth strategy is an alternative optimal strategy). Then all expected utilities may be ranked as

$$[u_1(\gamma_{1j}{}^*),\ u_2(\gamma_{2j}{}^*),\ \cdots,\ \text{etc.}]$$

for each alternative solution and the truly optimal solution could be located according to condition (16).

Lexicographic functions and satisficing behavior.—To represent satisficing behavior on the part of the decision-maker, the lexicographic utility function could include not only a ranking of the payoff factors but also the satisficing levels of the factors, d_i, $i = 1, \cdots, n$. The stochastic programming objective would then be to maximize the expected utility of the *least* important factor, subject to the attainment of at least the satisficing expected utility values of all other factors.[22] The stochastic programming objective, in this example to guarantee that the expected level of the ith factor is at least as great as the satisficing level d_i, could be set up as in (17).

(17) $$\text{maximize } E(u) = p'(w_{na} - w_{nb})$$

subject to

$$\begin{aligned}
-\sum_{t=1}^{T} \overset{(r)}{c}_{1t} x_t + \overset{(r)}{w}_{1a} - \overset{(r)}{w}_{1b} &= 0; \qquad r = 1, \cdots, k \\
p'w_{1a} - p'w_{1b} &\geq d_1 \\
\vdots \qquad\qquad &\qquad \vdots \\
-\sum_{t=1}^{T} \overset{(r)}{c}_{n-1,t} x_t + \overset{(r)}{w}_{n-1,a} - \overset{(r)}{w}_{n-1,b} &= 0 \\
p'w_{n-1,a} - p'w_{n-1,b} &\geq d_{n-1} \\
-\sum_{t=1}^{T} \overset{(r)}{c}_{nt} x_t + \overset{(r)}{w}_{na} - \overset{(r)}{w}_{nb} &= 0 \\
x_t,\ w_{ia},\ w_{ib} &\geq 0 \\
w_{ia} \cdot w_{ib} &= 0; \qquad i = 1, \cdots, n
\end{aligned}$$

where all variables and coefficients are as previously defined. If no feasible solution to (17) existed, the nth factor would be dropped from the objective and the expected utility value of the attainment of the $(n-1)$th factor would be maximized subject to the attainment of the satisficing levels of expected utility for all

[20] That is, $\alpha_1 > 0$ and $\alpha_i = 0$ for $i = 2, \cdots, n$.

[21] Alternative optima will exist if at least one nonbasic vector has a zero shadow price and if that vector can be included in the basis at a positive level (hence the alternative optima cannot simply be alternative degenerate optimal solutions); see [17, pp. 166–168].

[22] Halter and Dean have illustrated this approach, although only with a nonstochastic example; see [19, pp. 67–69].

other factors i, $i=1, \cdots, n-2$. This process would be continued until the first feasible solution was obtained.

The above objective function could be rewritten as multidimensional in *time* rather than in the number of payoff factors. For example, expected utility could be maximized subject to the requirement that expected utility of *each time period* was at least as great as a predefined satisficing level. Hence this approach would be another way in which account could be taken of interperiod variability in payoffs.

The choice of a utility function

If the analyst is satisfied that for the decision-maker utility is a function of one variable only, say net income, then by appropriate questioning the utility function may be derived [27, 29]. A graph of points in utility-net income space could then be constructed, from which the analyst can derive an estimate of the utility function's shape. He can then decide which of the functions of the above sections give the best approximation to that function, bearing in mind that some functions (for example, linear functions) are the simplest and probably least expensive to use (in terms of required computer time), and still others (nonconvex separable functions) require access to a specialized computing algorithm and may result in the location of local, rather than global, optimal solutions.

Should the decision-maker's utility be multidimensional, a similar procedure would be followed to establish each of the functions u_i, $i=1, \cdots, n$.

It should be remembered that whether the chosen function provides a good approximation to the underlying utility function will not simply depend on how closely the function fits the graphed points but rather on the sensitivity of "optimal" strategies to changes in the shape of the utility function, in the true value of expected utility as a result of such changes, and in the costs of implementing the various functions.

The Value of Additional Information

It is often of interest to a decision-maker to know the extent to which expected utility might be increased through the acquisition of additional information, or perhaps to know what it would be worth if all uncertainty could be removed from the decision problem. Since the discrete stochastic programming model can accommodate various information structures, it can also indicate the value of moving from one structure to another and the maximum amount the decision-maker could afford to pay to obtain such additional information.[23]

Where utility is one-dimensional and a linear function of money income, such values are easily derived provided that the model includes no restraints on cash supplies. Then the value of some additional information may be measured by subtracting the expected net income of the original ("no-data") optimal strategy from the expected net income of the Bayesian strategy which incorporated the additional information. Thus the quantity derived is the maximum amount of money that the decision-maker could afford to pay to obtain the additional information.

The above ex post determination may not be correct where the model includes cash restraints, since payment for the information may give rise to infeasibilities under some eventuating nature states. Also, where utility is a nonlinear function of money or is multidimensional, the above analysis would involve a comparison between two expected utility values. In all these cases a monetary value can be given to the additional information by determining that sum of money which, if added to fixed costs of the time period when the information must be paid for, would give, on problem solution, a strategy with an expected utility identical with that of the no-data strategy.[24] In other words, knowing the expected utility of the no-data strategy, the Bayesian programming model would be re-solved several times, with a successively higher addition to fixed costs, until expected utility became equal to that of the no-data strategy.[25]

Once a stochastic programming problem has been solved, the expected cost of uncertainty can be calculated by reformulating and solving

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[23] The approach adopted here to valuing additional information is an application of a method suggested by Harvey [20] and explained further in [19, pp. 132–138].

[24] Where utility is a function of several factors, fixed costs would only be entered in the rows of the matrix appropriate to the "cash" factor.

[25] This procedure will determine the *maximum* price that can be paid for the additional information. Of course, if the *actual* cost of the additional information is known prior to problem solution, this amount should correctly be added to fixed costs in the Bayesian problem. Then, provided that the expected utility of the Bayesian strategy exceeded that of the no-data strategy, acquisition of the extra information would be worthwhile.

the problem as one of passive stochastic programming.[26] Then all that is necessary is to determine that sum of money which the decision-maker could afford to pay for the perfect information and remain as well off, in terms of expected utility, as he would have been with the optimal strategy appropriate to the actual information structure.

Finally, the same procedure can be used to answer questions of factor acquisition under risk when the decision-maker's utility is a nonlinear function of money or multidimensional, or where the programming model includes cash restraints. For example, if a farmer had the opportunity to lease an additional 50 acres of land, two stochastic problems would be solved. The first of these would include the present land supply, and the second would include the additional land. Once an optimal strategy to the first problem had been obtained, the second problem would be solved several times with successively higher additions to fixed costs. When a strategy's expected utility became equal to that of the first (original) problem, the amount that had been added to fixed costs would represent the maximum price the farmer could afford to pay for the additional land.[27] It might also be of interest to compare this price with the increment in *expected income* that would result from purchase of the resource.

Summary and Implications

This paper has indicated how the sequential decision-theoretic problems often encountered in studies of farm and business management might be solved with the aid of discrete stochastic programming. The nature of this type of problem typically requires the allocation over time of limited supplies of resources among alternative production activities, where resource supplies, input-output coefficients, factor costs, and product prices may not be known with certainty at the various allocation dates.

It is believed that the usefulness of stochastic programming in solving such decision problems has been enhanced. Firstly, the paper has indicated how various information structures, particularly those involving forecasts, can be handled by the method; and secondly, it has demonstrated the manner in which a wide variety of expected utility functions can be specified as objective functions of the stochastic programming model.

The fact that such a wide variety of utility functions can be employed opens the door to many interesting studies such as the effect of decision-makers' preferences on resource allocation and valuation under risk within the firm. Thus it would be possible to test some theories (or formulate new ones) on optimal resource allocation under risk.[28]

Lastly, it has been shown that a money value may be imputed to additional information or increments to the firm's resource supplies. Thus the technique should be found useful in a wide range of Bayesian decision problems and in studies of factor acquisition under risk.

[26] Passive stochastic programming [34] assumes that the outcome of nature is known before any decisions must be made. It can thus be used to indicate the value of perfect knowledge of the future.

[27] It should be emphasized that once the *actual* cost of additional resources or information is known, the problem should be re-solved with the actual cost added to fixed costs to obtain the truly optimal strategy. The reason for this is the possibility of a change in optimal strategy occurring as the cost of extra resources or information is changed.

[28] This is a topic that has received considerable attention in the literature, since the traditional theory of the firm, which concentrated on optimal behavior under conditions of certainty, may not be satisfactory for situations involving risk. For example, [36] discusses the behavior of competitive firms; [15 and 38], the behavior of imperfectly competitive firms, under risk. In the latter case the stochastic programming model could approximate product demand and factor supply curves with step functions. Alternatively, by approximating the curves with linear functions, the decision problem would become one of quadratic programming, as demonstrated (for nonrisky situations) in [31].

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Optimum Dairy Plant Location with Economies of Size and Market-Share Restrictions*

DONALD W. KLOTH AND LEO V. BLAKLEY

Significant economies are possible under optimum organizations of the U. S. dairy industry, but models that minimize industry costs with a single firm in each market overestimate the potential savings. The effects of market-share restrictions for processing firms are estimated. Costs are higher than under single-firm organizations but remain below levels for the current plant-size environment. The major interregional effect of the restrictions is on the regional identity of the firms processing milk for local markets, not on the total quantity of milk transported between regions. With market-share restrictions, more milk is processed locally.

LEAST-COST LOCATION of agricultural processing industries can be approached through relatively simple models. Many of the more interesting questions, however, require results from more complex models which utilize assumptions, market definitions, and market restraints that approximate more closely the actual market environment. The purpose of this article is to report the development of a fairly realistic model and its application to the dairy industry of the United States. It assesses the effects on total costs and interregional flows of milk under alternative degrees of market concentration when economies of size of processing plants (not requiring constant marginal processing costs) are permitted.

Three levels of market concentration are specified. "Model A" permits only a single firm in each market, and references to this model will be in terms of unrestricted plant sizes. "Model B" involves specific maximum relative sizes of plants for each market. Generally two or more plants serve each market, and references will be in terms of a restricted plant-size environment. "Model C" is an approximation of the existing plant-size environment but is estimated by a less sophisticated model using estimated average processing costs for each area.

The Model

The production-distribution model formulated by Martin [10] is used as the beginning point for Models A and B. Martin's model can be considered as an extension of the Stollsteimer model [11] and determines the optimum number, size, and location of processing plants that will minimize assembly, processing, and distribution costs. A similar model was used with restricted spatial monopoly by Bobst and Waananen [1].

Separable programming is one technique for extending Martin's model to permit consideration of the size economies. Crowder [5] used the separable programming technique in a production-distribution model designed for a study of a closed Oklahoma dairy economy. Crowder's basic model is employed in this study.

The model in equation form has the objective:

$$\text{(1)}\qquad \text{Minimize } TC = \sum_{j=1}^{n}\sum_{i=1}^{m} C_{ij}X_{ij} + \sum_{i=1}^{m} f(X_i) + \sum_{k=1}^{p}\sum_{i=1}^{m} T_{ki}X_{ki}$$

subject to the constraints:

$$\text{(2)}\qquad \sum_i X_{ij} = D_j$$

$$\text{(3)}\qquad \sum_i X_{ki} \le S_k$$

$$\text{(4)}\qquad \sum_k S_k \ge \sum_j D_j$$

$$\text{(5)}\qquad X_{ki} \text{ and } X_{ij} \ge 0$$

where

TC = total costs for the assembly, processing, and distribution of milk for fluid consumption;

X_{ij} = quantity of processed milk shipped from processing area i to demand area j;

C_{ij} = per unit distribution cost of shipping processed milk from processing area i to demand area j;

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D_j = quantity of processed milk consumed in demand area j;

$f(X_i)$ = nonlinear function expressing the total cost of processing quantity X_i in processing area i;

X_{ki} = quantity of raw milk shipped from supply area k to processing area i;

T_{ki} = per unit assembly cost of shipping raw milk from supply area k to processing area i;

S_k = quantity of raw milk available in supply area k.

Economies of size in equation (1) are effective through $f(X_i)$, which is the representation of the nonlinear total cost curve for processing. The functional $f(X_i)$ can be used to approximate the cost curve to any degree of accuracy by substituting a number of linear transformations into a sum of functions of individual variables. If, for example, a function F can be written as

$$F = \sum_{i=1}^{m} f(X_i) \tag{6}$$

where

$$\sum_{i=1}^{m} f(X_i) = \sum_{i=1}^{m} \sum_{h=1}^{u} x_{ih}\theta_h, \tag{7}$$

x_{ih} is the hth variable of processing area i to enter the analysis, measured in terms of the quantity of milk in the hth interval, and

θ_h is the average processing cost associated with the quantity of milk in the hth interval,

then the function f (and, hence, F) can be approximated by piecewise linear functionals [3]. Separable nonlinear functions and the maximization of separable convex functions are discussed in more detail by Hadley [6, pp. 104–156]. The computer program employed is the IBM Linear and Separable Programming Routine [7, pp. 165–188].

Market share restrictions are imposed initially through maximum percentages of the local market permitted for individual firms. Specifically, the restriction is

$$X_{gij} < \alpha_{gj} D_j \tag{8}$$

where

X_{gij} = the quantity of milk processed by plant g in processing area i for demand area j, defined only for $i=j$,

α_{gj} = the maximum proportion of the market j served by plant g.

Ten relative plant sizes were specified for the analysis under Model A. A maximum of one plant was specified for any given market, but plant sizes were variable among markets. The selection of this plant (or importation of milk with no local plant) for a given market was from the smallest size of 7 percent of local consumption to the next to largest size of 10 million quarts per day, approximately the size when the minimum processing cost per quart is assumed to be reached (Table 1). A potential plant size larger than 10 million quarts per day (the special plant) was included as the largest size to give flexibility in the specifications for large markets or for exports to other markets. The 1965 producer Class I price structure was assumed for Model A.

Maximum plant sizes in the restricted market setting of Model B varied with the size of the market, the size sequence being reversed from that in Model A (Table 1). In the program the order of entry of plants is I, II, etc. For example, a second plant in a small market can enter the solution at a maximum capacity (or fraction of this maximum capacity) of 35 per-

Table 1. Maximum relative plant sizes specified for markets in models A and B

Plant number	Maximum plant size under: Model A		Model B	
	All size markets	Small-size markets[a]	Medium-size markets[b]	Large-size markets[c]
		percent of market sales		
I	7	55	55	55
II	15	35	30	25
III	35	10	10	10
IV	50	—[f]	5	7
V	115			3
VI	150			
VII	200			
VIII	250			
IX	—[d]			
Special plant	—[e]	50	50	50

[a] Markets with total sales of 75.0 million pounds per month or less.

[b] Markets with total sales of 75.1 to 150.0 million pounds per month.

[c] Markets with total sales in excess of 150.0 million pounds per month.

[d] Volume of 10 million quarts per day where the function approaches the assumed minimum cost of 1.8 cents per quart.

[e] Volume of up to 4.7 billion pounds per month, the total U. S. consumption.

[f] Blanks indicate not applicable, since no additional plant sizes in the market were permitted.

cent of the market sales only after the first plant is operating at the capacity specified by 55 percent of the market sales. The special plant can enter only when plants I, II, and III are operating. The primary function of the special plant is to provide for potential intermarket movements of packaged milk. The specifications are similar but with more potential plants and different share percentages for plants in the medium- and large-size markets. A base-point price structure based on 15 cents per hundredweight per 100 miles from Eau Claire, Wisconsin, is assumed for Model B.

A base for comparison is provided by the results from Model C, which uses estimated processing costs for existing numbers and sizes of firms in the industry. The 1965 producer Class I price structure was assumed. The models and the various restrictions employed are described in more detail by Kloth [9].

Data

Regions

The area of the study, which included the 48 contiguous states of the United States, was divided into 105 consuming markets and 92 areas of production. The delineation was based primarily on data furnished through correspondence with state agricultural agencies and federal order market administrators.

Production

Production of Grade A milk for the month of October 1965 was estimated for each county of the area. When county data were not available, estimates for markets or states were developed from class prices, average prices, average butterfat content, total milk production, and milk production not sold.

Consumption

Consumption was estimated for each market in order to have a uniform set of estimates for all markets. The building block for each demand area was the county. The estimated consumption for each market was the total population times the estimated per capita consumption for the market. The per capita consumption reflected the constant for the regional effect, the weighted average per capita income for the market and an assumed income elasticity of 0.16, the weighted average price in the market (from [12, pp. 36–39]) and an assumed price elasticity of −0.285, and a factor for the Caucasian population proportion in the market. The elasticity estimates are Brandow's [2, p. 17].

Costs

The assembly cost function relates to intermarket movement of unprocessed Grade A milk from production areas to processing areas. The cost function, based on Kerchner's [8] function for a 49,000-pound pay load is as follows:

$$T_{ki} = 11.405 + 0.1126M_{ki} \tag{9}$$

where

T_{ki} = assembly cost in cents per 100 pounds for transporting raw milk from a point in production area k to the point of processing in area i, and

M_{ki} = one-way mileage from production area k to processing area i.

The distribution cost relates to intermarket movement of processed Grade A milk from processing areas to demand areas. The cost function selected, also based on Kerchner's study, is as follows:

$$C_{ij} = 6.513 + 0.16025M_{ij} \tag{10}$$

where

C_{ij} = distribution costs in cents per 100 pounds for transporting packaged milk from processing area i to demand area j, and

M_{ij} = one-way mileage from processing area i to demand area j.

The processing cost function is one developed by Cobia and Babb [4]:

$$PC_{gi} = 11.763X_{gi}^{-0.11607} \tag{11}$$

subject to

$$PC_{gi} \geq K \tag{12}$$

where

PC_{gi} = processing cost in cents per quart for plant g in area i,

X_{gi} = quarts of milk processed per day by plant g in area i, and

K = 1.8 cents per quart, an assumed minimum.

Results of Plant-Size Restrictions

Firm numbers and sizes

An obvious expectation was that firm numbers would decrease and firm sizes increase from

Table 2. Distribution of Grade A fluid milk processing firms by size, region, and model fo the United States[a]

Region	Demand areas	Potential firms	Firms established: Total firms	Size classification (million pounds per month): Under 3	3 to 10	10 to 25	25 to 50	50 and over	Average firm size
	number		*number*						*million pounds per month*
Western									
Model A	21	21	13	0	1	5	5	2	57.9
Model B	21	88	55	14	21	13	4	3	13.7
West South Central									
Model A	14	14	9	0	1	3	0	5	43.0
Model B	14	56	30	3	14	9	4	0	12.6
Southern									
Model A	23	23	14	0	0	1	10	3	47.9
Model B	23	93	55	5	11	33	5	1	14.0
North Central									
Model A	35	35	16	0	1	3	4	8	112.2
Model B	35	145	76	7	27	20	15	7	21.2
Northeastern									
Model A	12	12	7	0	1	1	0	5	153.3
Model B	12	56	23	0	4	6	7	7	50.8
Total									
Model A	105	105	59	0	4	13	19	23	79.3
Model B	105	438	239	29	77	81	35	17	19.6

[a] Estimated numbers of firms for Model C: Western, 645; West South Central, 231; Southern, 587; North Central, 1524 and Northeastern, 562. It was estimated that approximately 90 percent of these firms had capacity of less than three millio pounds per month.

current levels under either Model A or Model B. The limit of reduction under efficient organization apparently would be indicated by the results from Model A, in which only 59 firms operated (Table 2). The largest facilities established for this model were in the Northeastern region—an average of 153 million pounds per month. This was followed by successively smaller average sizes in the North Central, Western, Southern, and West South Central regions in that order.

The imposition of plant-size restrictions in Model B resulted in about four times as many firms operating processing facilities as in Model A. The numbers of firms established at capacities of 50 million pounds or more per month were not greatly different in the two models except in the West South Central region. The greatest differences were in the numbers of smaller plants established, particularly plants with capacities of less than 10 million pounds per month. As a result, the average plant size was much smaller, 19.6 million pounds per month.

Cost comparisons

Total industry costs were not estimated. Omitted were (1) costs of assembly from the farm to the central location in the supply are and (2) costs of distribution from the potentia central processing location in each deman area through the retailing channels to the con sumers in that area. The latter costs tra ditionally are included in the distributor's cost at least those involved in transporting milk t retail stores and to homes via home delivery However, except for costs associated with du plication of services and differences in marke power, the omissions should affect only th share of total costs accounted for in the mode and should not appreciably affect the cost dif ferences among the models.

The costs of processing fluid milk in an in dustry with economies of plant size and wit excess plant capacity would be expected to de crease as the number of firms declined. The re sults were consistent with this expectation From $71.4 million for the current plant-siz environment (Model C), processing costs wer estimated to decline about one-third to $46. million when only a single firm operated in eac major market (Model A).

It is not necessary, however, to have only a single firm operating in each market to achiev significant reductions in processing costs. Unde the restricted plant sizes of Model B, processin

costs totaled only $54.2 million. In other words, two-thirds of the potential reduction in processing costs was achieved without limiting consumer choice to the product from only one firm in each market.

Fewer plant numbers are usually associated with fewer processing plant locations. This implies that both assembly costs for raw milk and distribution costs for packaged milk will increase as firm numbers decline. The implications will be valid, however, only if the comparative advantages among regions are unaffected by the changes in firm numbers.

Distribution costs followed the expected pattern and increased from $0.8 million for the current plant-size environment to $5.5 million for the single-firm organization. Over one-half the increase was associated with the change from the restricted plant size to the single-firm level of market concentration.

Assembly costs did not follow the expected pattern, although they were lower for the single-firm organization of the market than for the current plant-size environment. Assembly costs were highest for the restricted plant sizes (Model B) at $15.1 million, compared with $9.1 million for Model A, reflecting in part the impact of differential assumptions regarding price levels for milk. The price assumption for Model B was a basic Class I price in the upper Midwest plus a transfer cost to outlying points, while estimated 1965 Class I prices were used in Models A and C. The result was somewhat higher Class I prices in the more distant regions in Model B, which caused imports of raw milk from the Midwest to increase. The net effect was an increase in total assembly costs.

The total of processing, distribution, and assembly costs under the restricted plant-size environment was $71.8 million. Since total costs for Models A and C were $60.6 million and $83.8 million, respectively, the results indicate that only about one-half of the potential economies could be achieved in the restricted market setting, considerably less than the estimate of two-thirds based on processing costs considered alone.

Intermarket transfers

Model C provides a basis for estimating the minimum intermarket transfers of milk consistent with minimum costs for existing plants. The intermarket movements of raw and packaged milk totaled 2.1 billion pounds per month out of an estimated 4.7 billion pounds of final consumption. Only 4.8 percent of the intermarket transfers consisted of packaged milk, somewhat lower than the 7.3 percent reported for federal order markets in 1967.

Relaxing all market restrictions on firm numbers and sizes resulted in a substantial increase in intermarket transfers. The total for Model A was 3.1 billion pounds, an increase of one billion pounds over Model C. The increase was in intermarket transfers of processed milk, up to 26.7 percent of total processed milk.

In the restricted plant-size environment with more than one firm in each market (Model B), the results were intermediate between those in Model A and Model C. About 14.9 percent of total processed milk moved as packaged milk, approximately one-half the level indicated for Model A.

Interregional milk movements

Total interregional shipments of milk were substantially less than intermarket shipments and did not vary greatly among the models (Table 3). The total was a little less than one billion pounds for the five regions considered. The exports were from the North Central region.

Plant-size restrictions can affect the comparative advantage of processing firms in the various regions. For example, Model A indicates that the North Central region has a comparative advantage in generating economies of size in processing because of its location relative to production supplies, the demand of its large population base, and potential export markets. With an estimated plant size of 112 million pounds per month, there was an economic advantage and transhipments of the final product were indicated. About one-third of the exports from the region were as processed milk. With the plant-size environment made more

Table 3. Net regional monthly imports and exports of raw and processed Grade A fluid milk, Models A, B, and C

	Processed milk			Total milk		
	Model			Model		
	A	B	C	A	B	C
	million pounds					
	Net imports					
Net importing regions						
Western	0.0	0.3	0.0	44.2	373.3	60.2
West South Central	10.8	20.4	3.0	127.4	28.7	135.8
Southern	180.4	80.0	10.9	292.7	411.3	404.6
Northeast	122.2	26.1	27.1	457.6	139.3	321.3
	Net exports					
Net exporting region						
North Central	313.4	126.8	41.0	921.9	952.6	921.9

restrictive, the plants in the North Central region were unable to attain such economies. As a result, interregional shipments of raw milk increased and additional processing occurred in the more distant regions such as the West and South.

Net imports by regions indicated substantially larger interregional shipments for the West under Model B than under Models A or C. The differences reflect to some extent differences in the assumptions regarding relative prices as discussed earlier. Consequently, net imports for the Western area, and the corollary of unused production, may be overestimated in Model B. In the Northeast actual prices were somewhat higher than prices under the base-point pricing system, and the indicated net imports under Model B may be understated.

Conclusions

A model utilizing the separable programming technique was developed to permit minimization of assembly, processing, and distribution costs of the dairy industry with economies of size affecting the level of processing costs. This model was used to estimate the optimum number, size, and location of plants and the total costs when (1) no plant-size restrictions were imposed (Model A), and (2) maximum plant sizes based on market shares for each plant were specified (Model B). Results were also obtained for a model approximating the 1965 plant-size environment (Model C).

Production-distribution type models that minimize industry costs give results that overestimate the potential savings from reorganization of the industry. A substantial portion of such savings might be attributed to the economies associated with the establishment of a single firm in the local markets. This was the case in the present study. Using costs of $83.8 million per month in Model C as a base, potential savings of $23.2 million per month were indicated when no plant-size restrictions were imposed (e.g., single-firm market organization in Model A). About one-half of these potential savings would be eliminated if plant sizes were restricted to ensure that more than one firm should serve each major market (Model B). The plant-size restrictions of Model B resulted in about the same number of large plants as in Model A. However, there were more plants in Model B, and many markets were being served by plants with monthly capacities of less than 10 million pounds per month. These markets were in sparsely populated areas.

Large interregional shipments of milk were indicated by all models. Most of the regional exports would be from the North Central region at the 1965 price structure. With no plant-size restrictions, processed milk would be exported. With the current plant-size environment, the exports would consist primarily of raw milk.

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Time Horizon, Objective Function, and Uncertainty in a Multiperiod Model of Firm Growth*

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The growing literature pertaining to multiperiod programming models of farm growth raises three problems that are ordinarily solved with makeshift solutions: the duration of time to be included within the planning horizon; the arbitrage between present and future consumption; and the introduction of uncertainty. The connections between these questions are shown. The net worth of the firm at the end of the planning horizon is maximized under the constraint of a linear consumption function. In this case it is possible to use the turnpike theorem and some additional theorems on separability of matrices to derive a simple rule for deciding on the appropriate length of planning horizon. The introduction of uncertainty shortens the practical planning horizon defined according to this rule.

LINEAR PROGRAMMING farm growth models have recently caught the attention of many researchers [1, 2, 3, 28], and an extensive review of such models was published recently [14].

Three main problems are connected with this approach:

(a) The *objective function problem* lies in the fact that the choice between consumption and saving has to be taken into account. Thus, we have to express how plans made for the future influence present conduct.

(b) The *matrix size problem* comes from the necessity of setting up a submodel for each year up to the end of the planning horizon. The submatrices representing one year are disposed diagonally in the final matrix and linked together by investment and borrowing activities. Hence, if T is the number of years within the planning horizon and the annual submatrix is $m\times n$, the computation burden (m and n being fixed) grows on the order of T^3.

(c) The *uncertainty problem* is not confined to multiperiodic linear programming, since uncertainty is always present in any business decision. However, it may be argued that a good representation of behavior under uncertainty is needed much more for long-term planning than for annual decisions because mistakes are more easily corrected in the second case than in the first one.

These three problems may seem at first glance to be completely independent. Further inspection shows, however, that they are intimately connected. In part I we shall examine the relation between the objective function problem and the matrix size problem. In part II a proposal for maximizing the net worth of the firm at the end of the planning horizon will be investigated. The consequences of introducing uncertainty will be stated in part III, and in part IV an empirical example will be sketched.

I. Objective Function and Planning Horizon

The general line of argument developed here is the following:

(1) Modigliani's analysis [20] is the proper reference for defining requirements that a planning horizon ought to meet.

(2) Objective functions that belong to the family of the "present value" criterion never guarantee the existence of a horizon meeting Modigliani's requirements. On the contrary, maximizing the net worth of the firm at the end of the planning horizon under the constraint of a linear consumption function gives such an assurance, since it is possible in this case to apply the turnpike theorem.

(3) The arbitrariness involved in the choice of a linear consumption function is no greater than that involved in the choice of a discount rate.

(4) Selected theorems about the separability of matrices give a practical rule in deciding whether Modigliani's horizon is reached.

Defining Modigliani's planning horizon

The matrix size problem depends upon the length of time included within the planning horizon. Note that even if the decision-maker has great confidence in his plans, he knows that he will have to revise them as more information becomes available through time. Hence, long-run plans are not necessarily made up in order

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to be carried out, but only to utilize all the available information in making the best possible decision for the present period [20, 21, 24, 25]. The above reasoning leads to Modigliani's definition of the planning horizon: the time within which it is necessary to plan in order to make a decision for the first period.[1] However, this definition of the horizon implies that its length and even its existence will depend upon the objective function. For instance, maximizing the consumption of the nth period will obviously yield a horizon of n periods; maximizing the present value of the annual consumptions will obviously produce an infinite horizon if the rate of discount is negative. Therefore, the objective function should be chosen in such a way as to be sure that a planning horizon will exist and be not too long.

Consequences for the choice of an objective function

Two families of criteria have been proposed in literature for arbitrating between present and future consumption. The first family of criteria derives from the classical and neoclassical analysis of time preference for consumption, which leads to the definition of a rate of discount for the computation of "present values." Present values are computed only for consumption because no utility can be associated with the accumulation of capital goods per se. Therefore, the objective function is

$$F_1 = \sum_{t=1}^{T} C_t/(1+i)^t \tag{1}$$

where

C_t stands for consumption in period t;
i for the discount rate; and
T for the time at the end of the planning horizon.

With such an objective function, the existence of the required planning horizon is not always guaranteed.[2] Even so, the planning horizon is likely to be rather long for the following reason: Near the end of the horizon there will be a tendency to consume all consumable capital goods, since they will have no utility beyond the horizon. But capital goods are not consumable in general unless they can be converted into money. Therefore commodities whose life duration is longer than the planning horizon and whose salvage value is small will be penalized in short planning horizon programs. Since the criterion for determining the length of planning horizon is the insensitivity of the first-period programs to variation in the length of the horizon, such an effect will force a longer horizon.

An alternative means to stabilize the solution of the first period (and thus to shorten the horizon) is to introduce the value of investments in the computation of the utility index. This will lead to maximization of the present value of mixed functions. Such considerations are developed in [10].

Let us now turn toward the second family of criteria, which we may call the "linear consumption function model." There the choice between consumption and saving is made through the definition of a Keynesian consumption function. Let us define:

I_t : the income of period t
S_t : the saving of period t
C_t : the consumption of period t
a : an exogenous variable $(1 \leq a \leq 0)$

then

$$S_t = aI_t, \quad \text{and} \quad C_t = (1-a)I_t. \tag{2}$$

This rule has several interesting properties: (1) Maximization of the sum of the consumptions of the different periods is equivalent to maximization of the net worth of the firm at the end of the horizon. (2) The existence of a planning horizon is guaranteed. (3) This planning horizon is relatively short. (4) The necessary assumptions are no more arbitrary than those required by the present-value criterion.

II. The Properties of the Linear Consumption Function Model and the Matrix Size Problem

The equivalence of maximizing consumption or wealth under the linear consumption function

The linear consumption function may be used

[1] "The decision problem of the firm at any point of time is that of choosing an optimal first move rather than that of establishing a plan of action as suggested by much of the existing theory of the firm. The problem of choosing the plan that will maximize the outcome of the firm's activity can be reduced logically to the problem of solving a system of simultaneous equations involving all future parameters and moves. This system, however, needs to be 'solved' only with respect to first move. It is suggested that the system of equations may partition in such a way that the solution for the first move may be obtained from a subset of the entire system" [20, p. 482].

[2] Malinvaud [18] had studied the case with only one capital good, whose life duration was only one year. Even with such stringent assumptions, he does not reach very general conclusions about the existence of a planning horizon in Modigliani's sense because the result always depends upon hypothesis of the production function.

with any objective function. However, if, as stated before, utility can only be associated with consumption, it is natural to maximize

$$F_2 = \sum_{t=1}^{t=T} \alpha_t C_t, \tag{3}$$

α_t being a weight attached to period t.

To choose an appropriate α_t may appear just as cumbersome as to choose a discount factor for the computation of present values. But since consumption and saving are tied together by equations (2), we can define

$$\beta_t = \frac{1-a}{a}\alpha_t \tag{4}$$

and maximize

$$F_3 = \sum_{t=1}^{T} \beta_t S_t \tag{5}$$

The search for "suitable" β_t's is then equivalent to the search for proper α_t's. F_3 may be interpreted as the net increment of the aggregate stock of capital goods, each good evaluated at a price that may vary according to the year in which it is produced.

Moreover, since F_3 is defined up to a constant, we may add to F_3 the value of the initial endowment of capital without changing the optimal solution. Therefore F_3 may be identified with the net worth of the firm evaluated at prices that are still to be determined but that depend upon the β_t's by relations of the form:

$$P_i = \frac{\sum_{t=0}^{T} y_i \beta_t \dot{K}_{it}}{\sum_{t=0}^{T} \dot{K}_{it}} \tag{6}$$

where

- P_i is the price of capital good i for the computation of the net value of the firm;
- $\dot{K}_{it}$ is the net increment of capital good i in year t in the optimal program;
- y_i is the "basic" price of capital good i;
- β_t is the weight of period t previously defined.

Thus, if we define:

$$\dot{K}_i = \sum_{t=0}^{T} \dot{K}_{it} \tag{7}$$

we are led to maximize

$$F_4 = \sum_i P_i \dot{K}_i \tag{8}$$

By equations (5) and (7), we have

$$F_4 = \sum_i \sum_{t=0}^{T} y_i \beta_t \dot{K}_{it}, \tag{9}$$

and thus

$$F_4 = \sum_t \sum_i y_i \beta_t \dot{K}_{it} \tag{10}$$

Since, by definition,

$$S_t = \sum_i y_i \dot{K}_{it}, \tag{11}$$

we can write

$$F_4 = \sum_{t=1}^{T} \beta_t S_t = F_3 = F_2 \tag{12}$$

Therefore, we may replace our search for suitable β_t's by a search for suitable p_i's, i.e., *for suitable prices to evaluate the net worth of the firm at the planning horizon.* This transformation of the initial problem, as defined by equation (3), will enable us to make use of the "turnpike theorem."

Introducing the turnpike theorem to ensure the existence of a planning horizon with a linear consumption function model

Let us first recall the set of propositions known as the "turnpike theorem." Let k_t be the vector of the stocks of the different capital goods existing at the end of period t, and p the vector of the prices P_i of capital good i. One seeks to maximize

$$F_5 = p(A+B)k_t, \tag{13}$$

subject to

$$\begin{aligned} (A+B)k_t - Bk_{t-1} &\leq 0 \\ k_t \geq 0 \qquad (t &= 1 \cdots T). \end{aligned} \tag{14}$$

The initial capital stock k_0 is given, and A and B are submatrices of the yearly matrix of input-output coefficients of the linear programming model. The construction of A and B from the yearly input-output matrix may be sketched as follows: Consider the classical case where the activity "wheat" consumes x acres of land and y hours of labor in the appropriate lines of the matrix and produces, in another line, z dollars of money. One may convert the activity "wheat" into an activity "land devoted

to wheat," which is a kind of capital good. This latter activity consumes y hours of labor and produces z dollars of money in the corresponding lines of the submatrix A. It consumes x acres of land in the submatrix B, and this land is available for the next period, through the coefficient $(-Bk_{t-1})$ in equation (14).

Similar transformations can be performed on almost all the activities of a "classical" farm matrix. At the end of the process almost each line of the initial matrix will have at least one corresponding capital good. The only lines that that do not satisfy this condition are those which express "absolute" constraints, e.g., land if there are no land-purchasing or land-hiring activities in the model. Therefore, what follows implies that the model does not contain such constraints; i.e., there are no absolutely fixed factors.

This being granted, the solution of the equation system (13) and (14) depends upon both p and T. However, if T is large enough, the turnpike theorem states that the solution becomes independent of p and T, and depends only upon k_0 and (A, B) [26, 16, 11].

To make this statement more precise we shall need one more notion. Let us designate by $d(z, w)$ an indicator of the angle between the two vectors z and w (one can write, for instance,

$$(15) \qquad d(z, w) = \sum_i \frac{z_i}{\sum_i z_i} - \frac{w_i}{\sum_i w_i}$$

where w_i and z_i are the elements of z and x). Then, under some additional assumptions [26], the solution of the equation system (13), (14) has the following property: For any $\epsilon>0$, there is a number N and a vector k^* such that for $T>2\,N$,

$$(16) \qquad d(k_t, k^*) < \epsilon$$

for $N \leq t \leq T-N$.

k^* depends only upon the annual submatrix (A, B).

A similar theorem holds for the corresponding dual problem, the variables of which are the elements of the shadow price vector u_t, where u_t approaches a vector u^*, which depends only upon (A, B). Therefore, if ϵ is sufficiently small, and since the number of feasible bases is finite for $N \leq t \leq T-N$, the optimal subbases[3] will be identical with each other, and we shall have

$$(17) \qquad k_{t+1} = \lambda k_t = \lambda^{t-N} k_N$$

λ is the maximum rate of growth of any weighted sum of the k_{it}''s which is permitted by the technology (A, B).[4]

The sequence of the k_t''s for $N \leq t \leq T-N$ is called the "von Neumann path" of growth [27].

The interpretation of the theorem may be stated as follows: The optimal rate of growth λ can be reached only if the initial endowment of the firm has the structure of the von Neumann vector, k^*, so that $k_t = \rho k^*$, ρ being a scalar. As this is not the case, in general, for a long planning horizon, the first decisions aim at reaching this optimal structure. Conversely, near the end of the planning horizon the desirable structure of the last output, as defined by the weight of these outputs in the objective function, may be different from the optimal growth structure, u^*. Then the aggregate growth slows down because of departure from the optimal growth path, a part of the capital stock is unexploited, and priority is given to the most desired assets.

If the planning horizon is too short, the system may never converge towards the von Neumann path but may remain in the first or in the last stage. On the contrary, if the planning horizon is "long" it will always be beneficial to make use of this path. This explains the name of "turnpike theorem," by analogy with the case where it pays to use a turnpike road instead of taking a more direct but narrower road between two distant towns.

Thus the "turnpike theorem" shows that it is always possible to define a planning horizon so long as the pricing of the desired commodities at the end of the horizon has no influence on the decisions of the first periods. In this case the economic system represented by the model will converge towards the von Neumann path of expansion, whatever the initial situation and the final desired proportion of commodities, provided that the number of periods is large enough. Hence, if this condition is satisfied, the maximization of any quantity related to the final output (for instance, liquid saving) will lead to the same decisions in the first periods. The preceding statements are visualized in Figure 1, for the case of two capital goods, k_1 and k_2.

[3] We mean by subbasis the subset of a basis of the linear programming problem defined by the vectors of the basis belonging to the same submatrix.

[4] Several proofs have been proposed; see [12, 16, 26].

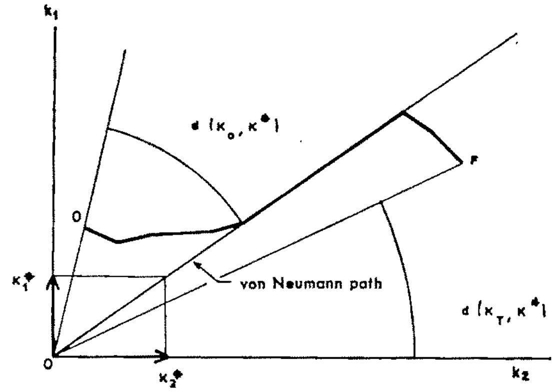

Figure 1. The access to the turnpike with a two-capital goods model[a]

[a] The slope k_1^*/k_2^* of the von Neumann path is a characteristic of the "technology," i.e., the annual submatrix used. The coordinates of point 0 are k_{10} and k_{20} and correspond to the initial endowment. The coordinates of F define the stock of capital at the end of the accumulation process. The points between 0 and F on the curve represent the subsolutions of each annual submatrix of the multiperiodic linear programming, beginning with the stock represented by 0 and ending with the stock represented by F.

This affords us a solution to our problem of choosing suitable p_i's, since we now see that with a "long" planning horizon the system of p_i's does not matter at all, at least for the first-period decisions. However, this raises once more the matrix size problem, in that the von Neumann path is sometimes reached only after many periods.

Using the decomposability theorems to reduce the size of the matrix

Fortunately, we may use the theorems pertaining to the decomposability of matrices to overcome the matrix size problem. In general terms, these theorems may be explained as follows:

Consider a *principal* problem, defined as to maximize

$$V = c_1x_1 + c_2x_2 \tag{18}$$

subject to

$$\begin{aligned} &A_{11}x_1 + A_{12}x_2 \leq 0 \\ &A_{21}x_1 \leq 0 \\ &x_2 \geq 0, \quad x_1 \geq 0, \end{aligned} \tag{19}$$

where c_1, c_2, x_1, x_2 are vectors, and A_{11}, A_{12}, A_{21} are matrices. Let $\hat{u}_1$, $\hat{u}_2$ denote the optimal vectors of dual values, and $\hat{x}_1$, $\hat{x}_2$ the vectors of the solution.

Then, define a *reduced* problem by the maximization of

$$V' = c_1x_1 - \hat{u}_2A_{11} \tag{20}$$

subject to

$$\begin{aligned} &A_{11}x_1 \leq 0 \\ &x_1 \geq 0 \end{aligned} \tag{21}$$

One can demonstrate [4, 5] that under rather general assumptions $\hat{x}_1$ is an optimal solution of the reduced problem. Conversely, $\hat{x}_1$ is a part of the optimal solution of any principal problem maintaining unchanged the quantity $\hat{u}_2\ A_{11}$.

Now, in a multiperiodic program, A_{21} may represent the submatrices of the first few planning periods and A_{12} those of subsequent periods that we would be able to drop. Therefore, A_{11} is the submatrix that joins the last maintained and the first suppressed period. It may always be rearranged so as to have

$$(A_{11}, A_{12}) = \left[\begin{bmatrix} -I \\ 0 \end{bmatrix}, \begin{bmatrix} I & 0 \\ A_{32} & A_{33} \end{bmatrix}\right] \tag{22}$$

where I stands for the unitary matrix of size $n \times n$, if there are n different outputs and 0 is a matrix, all elements of which are zero, whatever its dimensions.

Then, we may write

$$\hat{u}_2A_{11} = k_tu_t \tag{23}$$

where k_t is the row vector of the outputs of period t, and u_t the column vector of m rows, the elements of which are the dual values of the upper rows of the matrix (A_1, A_{12}) in the principal problem. Note that k_t and u_t have here exactly the same definition as in the preceding section.

Moreover, in the von Neumann model $c_1 = 0$, since no activities have nonzero coefficients in the objective function except those of the last period. Thus the equation system (20), (21) may be restated so as to maximize

$$V'' = k_tu_t \tag{24}$$

subject to inequations (21). But how should we determine t and u_t? Let us call u_t^0 and k_t^0 the values of u_t and k_t when the planning horizon is long enough to enable the system to reach the von Neumann path. The problem of finding the sequence of u_t^0 and k_t^0 will be called the "unbounded time access problem" to the turnpike.

In order to reduce the matrix size, it would be helpful to compute u_1^0. Unfortunately, the computation of u_1^0, from (A, B) and given k_0, though certainly not theoretically infeasible, seems to lead to inextricable complications.[5] The simplest approach would probably be to solve the large multiperiod L.P. over a time T sufficiently long to reach the von Neumann path.

However, it is not necessary to compute *exactly* u_1^0. Approximate values are sufficient to produce the same results as we shall now show. By the separability theorem, if at time n, $u_n = u_n^0$, then for all $t \leq n$ we shall have

$$u_t = u_t^0 \tag{25}$$

Furthermore, note that the product $k_t^0 u_t^0$ is the maximal value of any feasible $k_t u_t$, such that

$$d(u_t, u^*) \leq d(u_t^0, u^*) = \epsilon_t^0, \tag{26}$$

where ϵ_t^0 is the distance between the turnpike and the unbounded access path at time t. Otherwise, since there are no constraints on u_t^0, it would have been possible to increase the objective function of the unbounded time access problem.

Now, consider the (new) problem I: Maximize pk_{2T} over a horizon of length $2T$, under the additional constraint that

$$d(u_T, u^*) \leq \epsilon_t^0 \tag{27}$$

Then, if u_t^0 is feasible in I, the couple (u_t^0, k_t^0) will be the optimal solution of I at time T.

Conversely, consider the truncated dual problem II over the interval $(T, 2T)$: Minimize

$$u_T' k_T',$$

under the constraints:

$$\begin{aligned} d(u_T', u^*) &\leq \epsilon_T^0 \\ u_{2T} &\geq p. \end{aligned} \tag{28}$$

Since k_T^0 is feasible and (u_T^0, k_T^0) are optimal, the couple u_T^0, k_T^0 is the solution of II for period T. And since the feasible set of II is a subset of the feasible set of I, u_t^0 is feasible in I. Therefore, (u_T^0, k_T^0) is the optimal solution of I, and by equation (25), the subsolution of the unbounded time access problem over the interval $(0, T)$ will be the subsolution, over the same time, of any problem of length $2T$ or more and satisfying equation (27). Figure 2 illustrates this statement.

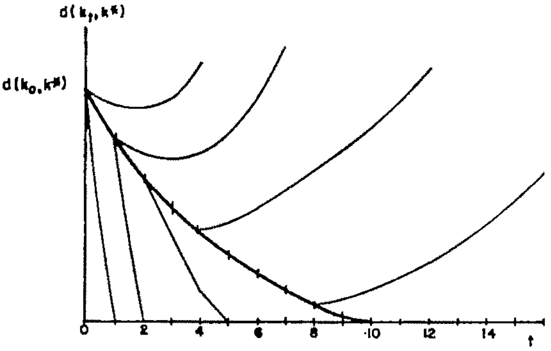

Figure 2. Difference over time between the von Neumann path and the solution of several problems, differing only by the objective function and the planning horizon.

Thus, not only is there a convergence towards the turnpike for a sufficiently long planning horizon but there is also a convergence towards the optimal access path to the turnpike, so that a wide range of objective functions will lead to the same optimal first step, even for horizons much shorter than those that are necessary to reach the von Neumann path. On the contrary, if the system does not lead to the optimal first step, it is likely to be much more sensitive to slight changes in the coefficients of the objective function.

These last remarks enable us now to set up a practical rule for the determination of t and u_t and, consequently, for the solution of our problem of evaluating the P_i's previously defined. Start by arbitrarily evaluating the assets in the objective function defined as the firm's net worth at the planning horizon, with an horizon of a few years (five may be a suggested order of magnitude). Perform a sensitivity analysis to check whether wide changes in the objective function affect the first subsolution. ("Wide" changes are changes much wider than those that lead to important changes in the optimal basis when the horizon is only one year.) If such changes arise, take a longer horizon. Following this rule, the planning horizon will be shorter as the starting function is nearer to u^*. But how does one choose a starting function "not too far from u^*"? Although there are no reasons why the current prices should be the elements of u^*, there is strong evidence that they cannot lie too far from it since they are constrained (among other things) by the technology at hand. Thus they seem to be an acceptable starting function. This is the final justification for

[5] An introduction to the problem raised can be found in [11].

maximizing the net worth of the firm at the end of the planning horizon, where planning horizon is sufficiently long as to make the solution of the first period insensitive to wide changes in the prices chosen for the evaluation of the assets.

Final comment on the arbitrage between present and future consumption

The preceding discussion, even if it helps to clarify the problem, does not allow us to circumvent the fundamental question of the comparability of consumption in different periods of time. We have seen that the criterion of maximizing the net worth of the firm under the constraint that a fixed proportion of income should be consumed each year is rather appealing, mostly because it provides an elegant way to define Modigliani's planning horizon. On the contrary, the various present-value criteria do not guarantee the existence of such a horizon.

However, one may argue that such considerations are insufficient in the choice of a criterion and that the theoretical strength of the analysis on which the present-value criteria are based is so great as to outweigh the practical advantage emphasized here. One might also point out the arbitrariness involved in the choice of a linear consumption function. However, exactly the same arbitrariness arises with the present-value criteria. In choosing the "correct" discount rate for the computation of present values, the only possible reference is the "rate of interest" on the financial market, considered as reflecting the equilibrium of supply and demand of saving. But we are viewing the situation from the standpoint of the individual; hence it is inconsistent to use a coefficient that is significant only at an aggregate level. Moreover, several rates of interest exist at any point of time, and this would confront the model builders with another difficult choice. Last but not least, the rate of interest for a particular transaction does not express the aggregate preference for present timing as opposed to future timing but only the tensions that exist at a given moment on the financial market.

Therefore, we conclude that it is erroneous to state that the rate of discount for present consumption can be better justified theoretically than the fixed saving/income ratio. The latter is simpler and is well documented by famous empirical studies [13].

III. Uncertainty and the Planning Horizon

Since the principal condition for applying the turnpike theorem is the absence of "absolute" constraints in the model, it is no longer possible to introduce such things as "flexibility constraints" in the matrix. Moreover, when assuming mean values for all the coefficients it often happens that the mean marginal productivity of money is higher than the borrowing interest rate. In that case, without absolute constraints, the solution of the problem is infinite.

The introduction of uncertainty in the model by reducing the feasible set generally avoids this kind of misfortune. First, we shall recall some results about uncertainty in a monoperiod model. Then we shall extend this model to the multiperiod case and interpret it within the framework already built.

Uncertainty in a static setting

There is an abundant literature discussing optimal behavior under risk and uncertainty.[6] However, in practice their differences vanish more or less, and the results depend almost exclusively upon the evaluation of the risk-aversion parameter which is included in all of them [6, 22]. Therefore, we can treat uncertainty with a "focus loss constrained programming" [8, p. 80–90; 9] without losing too much generality. In this model the objective function is expressed independently of the risk. Therefore all the previously defined objective functions may be implemented.

The disutility tied to the fluctuations of outcome is expressed by a set of "risk constraints" whose purpose is to ensure that the likelihood of "ruin" is very small. The measure of risk and uncertainty is not expressed in terms of probabilities. Rather, expectations pertaining to gains and losses associated with each activity are described according to Shackle's analysis [24, 25]. One assumes that the decision-maker concentrates his attention on *a focus of loss* and *a focus of gain*, depending both on the likeliness and the importance of possible losses and gains. The focus of loss is the minimum outcome that the decision-maker would consider, and the focus of gain is the corresponding value for gains.

The difference between the focus of loss and the focus of gain on activity i is the possible loss, L_i on the activity. This possible loss is assumed to be proportional to the level of the activity i. Thus, if x_i is the level of the activity i, and l_i its possible loss at the unit level, then

[6] It is impossible to quote here the authors who treated the question. A brief review of the main theories is made in references [6] and [9]. Merrill [19] tried to solve a problem analogous to this one.

$$L_i = 1_i x_i \tag{29}$$

At the farm level, one defines a *permissible loss*, L_0, as the difference between the inflow of the "normal" receipts (i.e., the receipts corresponding to the foci of gain) and the inescapable expenses. Thus, letting

m_i = the unitary gross receipts on the ith activity at the focus of gain level,
e_i = the corresponding current expenses,
C_m = the farmer's "vital" consumption,
F_m = all the compulsory payments not included in the e_i's, and
i^* = the number of activities,

one has

$$L_0 = \sum_i (m_i - e_i)x_i - (C_m + F_m) \qquad (i = 1 \cdots i^*) \tag{30}$$

Now, the principal assumption (and the least justified one) of the model is that the security constraints are fulfilled if the following inequations are satisfied:

$$1_i x_i - L_0/\delta \leq 0 \quad (i = 1, n)^7 \tag{31}$$

δ is a coefficient, the value of which was set to 3.0 in all the applications of this model on the basis of a rough probability calculus previously developed [9, p. 164].

Even in a static framework this model explains some aspects of the behavior of farmers, especially from the financial point of view. Among the e_i's one is especially important; namely, the level of short-term borrowing, $a_0 \cdot a_0$, depends upon the total current cost, and the level of the initial liquid endowment, D, on the necessity of financing current expenses:

$$\sum_i e_i x_i - a_0 \leq D. \tag{32}$$

Therefore, equation (30) can be rewritten:

$$\sum_i (m_i - e_i)x_i - L_0 - a_0 = C_m + F_m \tag{33}$$

The highest l_i's are generally associated with the highest m_i's, the highest e_i's, and the highest $(m_i - e_i)$'s. This is a natural consequence of the fact that the more intensive speculations are also the riskiest ones. An important consequence of this fact is that raising the level of the riskiest (and more profitable) activities implies also raising a_0 when $\sum_i e_i x_i \geq D$. But by equation (33) this also implies a lower L_0, and since at the same time equation (31) shows that the factor $l_i x_i$ is increasing for those activities whose levels are increasing, there is soon an upper limit to this growth. Therefore, the borrowing activity is self-constrained.

But this analysis, fully developed in [9], is still insufficient, because in a static framework it is impossible to relate D to other investment opportunities. Also, the farmer may keep aside some liquid assets as a reserve fund in order to overcome temporary difficulties. These considerations can be included in a multiperiod model.

Implementing the model in a dynamic framework

Let us add an additional subscript, t, denoting time, to the variables that were defined in the preceding paragraph. Moreover, let us define:

R_t = the level of reserves at the beginning of period t;
$\dot{R}_t$ = the increment (positive or negative) of R_t;
a_{jt} = the annuities of long term debt repayment on the jth borrowing;
j^* = the maximum value of j, i.e., the number of borrowing activities;
H_t = the amount of money diverted from the liquid flow of the farm to buy capital goods (the life duration of which is more than one year) at the beginning of period t;
M_t = the amount of liquid money in cash at the beginning of period t.

Then, as with any other capital good,

$$R_t = R_{t-1} + \dot{R}_t \tag{34}$$

R_t is determined jointly with H_t and D_t by

$$H_t + D_t + \dot{R}_t - M_t \leq 0 \tag{35}$$

Moreover, each year, a fraction $1/\delta'$ of R_t can be used to cover an eventual deficit and, therefore, to increase L_{0_t}. Thus, equation (34) is rewritten:

$$\sum_i (m_i - c_i)x_{it} - L_{0t} - a_{0t} + 1/\delta' R_t - \sum_j a_{jt} \leq C_{mt} + F_{mt} \qquad (j = 0, \cdots, j^*, i = 1 \cdots, i^*), \tag{36}$$

[7] Note that n may be different from i^* because activities whose possible losses are tied together may be grouped in these equations.

M_t is determined by equation (37), which expresses the equilibrium of the cash flow:

$$M_{t+1} = \sum_i (m_i - c_i)x_{it} - \sum_j a_{jt} - C_{nt} - F_{nt} + V_{1t} + D_t \quad (j = 1, \cdots, j^*, \; i = 1, \cdots, i^*) \tag{37}$$

where

C_{nt} stands for the "normal" consumption of period t (defined by equation (2));
F_{nt} for the "normal" fixed costs (if any);
V_{1t} for the monetary countervalue of the capital goods sold during period t.

Moreover, D_t is used to finance short-run expenses concurrently with a_{0t}:

$$\sum_i c_i x_{it} + \sum_j a_{jt} + C_{nt} + F_{nt} \leq D_t + a_{0t} \quad (j = 1 \cdots j^*; \; i = 1 \cdots i^*) \tag{38}$$

The relations (31) are rewritten for each year:

$$1_i x_{it} - L_{0t}/\delta \leq 0 \quad (i = 1 \cdots n) \tag{39}$$

Thus, the set of relations (34) to (39) can be inserted in a classical multiperiod programming model. What kind of effects do they produce?

Consequences for the planning horizon

The preceding discussion of turnpikes and objective functions need no specification of the type of annual submatrix employed. However, the practical implications of these concepts are highly dependent upon the structure of this submatrix. For instance, if all the assets are perfectly liquid (i.e., salvage values equal acquisition values at any point of time, so that no loss is associated with selling or acquiring capital goods), then the turnpike will be reached at the beginning of the first period and the growth path will follow it up to the beginning of the last period, since it will be possible at this time to change the proportions of the assets in accordance with the objective function.

However, in general, exchanging one capital good for another is costly because the salvage value is smaller than the acquisition value. Thus, access to the turnpike is not instantaneous. The larger the difference between the salvage value and the acquisition value, the larger the time elapsed before the optimal access path reaches the turnpike.

What is the impact of introducing into the technology the submatrix pertaining to uncertainty described in the preceding section? It slows down the growth and reduces the length of Modigliani's horizon by reducing the annual feasible set. For instance, a marginal downward movement of D_t will normally entail an upward movement of a_{0t}, to keep the solution feasible, by relation (38). But a rise in a_{0t} will induce a lowering of L_{0t} in (36) and, by (39), will result in a reduction in the feasible set of speculative production possibilities. This will lower the expected income. Therefore, by (2), C_t will be reduced; and M_{t+1} will also be reduced through relation (37). Thus, the feasible set of year $t+1$ will also be reduced and, consequently, those of the subsequent years. The same reasoning may be used for marginal variations of H_t. Therefore, the introduction of the security submatrix reduces the feasible set and the possible rate of growth and makes it more difficult to change the structure of the initial endowment.

If we start from a technology matrix without security constraints, introducing them will define a new turnpike whose optimal rate of growth will be lower than the former. The optimal access path will be longer, since reducing $d(u_t, u^*)$ will be more difficult. At the same time, the feasible set will be restricted. Therefore, the maximal feasible $d(k_t, k^*)$ will be also reduced. Thus, a diversion from the optimal access path to the new turnpike will be made more difficult. In general, this will reduce the length of the planning horizon and the importance of the choice of the prices in the objective function.

IV. Some Empirical Results

The preceding conclusions can be illustrated by a single application. In the annual submatrix four activities represent four kinds of enterprises: grain, animal breeding, field vegetables, and hothouse crops. Two periods of work and soil occupation were defined—summer and winter. One row expresses the necessity of maintaining the humic soil balance through animal breeding or purchase of manure outside the farm. Another row expresses the necessity of buying water for irrigation. Temporary labor can be hired in the summer on an hourly basis. Permanent farm workers can be employed if they are paid during the whole year. The complete description of the model can be found in [7]. The results follow.

The access to the turnpike

Several lengths of the planning horizon were tried, from one to seven years, with two prices

for evaluating the land in the objective function ($3,900 per acre and $1,300 per acre). As expected, with the one-year horizon, the two first-year subbases corresponding to the two land values were quite different. With the seven-year horizon, on the contrary, they were not formally identical, but the values of the key variables differed only by a few decimal digits.

Rigorously speaking, we cannot affirm that this solution for the first year is the true first move towards the turnpike along the optimal access path. However, considering the wide range of variation for the price of the most important commodity in the model, this is likely.

Significance of the solution

The model was solved for three different initial endowments: the first farm had a large acreage and a reasonable amount of cash; the second farm had a medium-sized acreage and the same amount of cash; and the third farm had no acreage but had the equivalent value in cash, at selling price, of the initial acreage of the first farm. All three had the same number of family workers. The matrices were identical in the three cases.

As was expected, cereals crops entered the solution at a high level in the first farm. The second farm divided its acreage between cereals and vegetables. The third farm went into the glasshouse business (Table 1).

Table 1. Solution for the first year of a multi-period model over seven years, for different starting points

Activities	Starting point		
	Initial surface, 45 acres; initial fund, $5,000; two men	Initial surface, 180 acres; initial fund, $5,000; two men	No initial surface; initial fund, $90,000; two men
Cereals (acres)	28.62	164.00	—
Grazing (acres)	6.87	—	—
Vegetables (acres)	10.91	26.67	—
Hothouses (square yards)	—	—	3,700

This result has theoretical and practical implications. From a theoretical point of view, the turnpike is completely defined by the "technology" depicted by the annual submatrix. Two farms standing on the turnpike will have exactly the same plan, up to a proportionality coefficient. If there are no economies of scale, all the farms belonging to the same region or in the same environment must be represented by the same technology. Therefore, all the plans of such farms should converge towards one another so that at the end they should have exactly the same structure. Such a conclusion obviously contradicts reality. However, the reasoning on which it is founded does not take into account the time that is necessary before the optimal access path reaches the turnpike. As this time may be very long, the starting point is the main factor for determining not only the first move but also the solution for several periods along the access path. Furthermore, the environment will change, consequently changing the technology and the turnpike. Therefore we can understand why the turnpike may never be reached despite the fact that everybody aims at reaching it.[8]

From a practical point of view, this model need not rely on the introduction of economies of scale or on the assumed difficulty for the farmer to switch from one activity to another (flexibility constraints)[9] in order to explain the variety of farm production systems. Initial endowment of inputs is quite sufficient to account for different production patterns, provided that the problem is treated in a dynamic setting including uncertainty considerations.[10] This result may be interpreted as an empirical test of Johnson's "theory of fixed assets" [15].

[8] On the other hand, we may notice in many rural societies which have known a stable environment for a long period of time that the farm organizations are quite similar to each other. It would be interesting to see whether, in such cases, all the farms are remaining in a kind of turnpike whose rate of growth would be very low.

[9] One may suspect that the rather arbitrary coefficients δ and δ' introduced in the security submatrix play the role of disguised flexibility constraints. This objection is unfounded since they never change with the situation to be represented, contrary to the flexibility constraints, whose level is characteristic of each starting situation. Besides, as we have previously pointed out, the crucial factors for the stability of the solutions are (a) the difference between salvage value and acquisition value and (b) the 1_i's. Experience with a dozen models built along this line shows that manipulating such coefficients is the best practical way to "improve" an "unsatisfactory" solution. However, since these values are data coming from observation, manipulations of such coefficients cannot exceed certain limits (as for work-time coefficients, for example). This preserves the scientific value of the conclusions drawn from these models.

[10] Removing the uncertainty constraints would have yielded an unbounded solution because the marginal productivity of glasshouse building (including the corresponding land buying) was higher than the rate of interest. Thus, glasshouse building and short-run borrowing would have been unbounded.

Summary and Conclusion

We have examined the relations between the three main problems associated with multiperiod farm growth models. We are led to define the planning horizon accordingly to Modigliani and the objective function as the net worth of the firm at the end of the planning horizon. The arbitrage between present and future consumption is made through a marginal propensity to save, and this solution is no more arbitrary than the alternative solution of maximizing the present value of consumption. Uncertainty is taken into account in the model through the generalization of a previously developed static model. Its most important role is to reduce the feasible set and the length of the planning horizon by cutting down the investment possibilities and by making the conversion of one asset into another more difficult.

An empirical test of the model emphasizes the importance of the initial resource endowment on the decisions of a farmer in the determination of the first-period solution. Models built along these lines demand considerable data pertaining to farm "structure," such as initial endowment of financial reserves, current prices for the different possible assets, and institutional rules for buying and selling the assets, such as land and loan. These "structures" carry considerable weight in explaining farm production and supply responses.

Thus, it would be possible to use this model to study farm production on a regional or national level along the general line of the studies carried out by Day [11] and Schaller [23]. However, the farm model would not require the arbitrary assumptions that the flexibility constraints entail.

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A Supply Response Model for Perennial Crops*

Ben C. French and Jim L. Matthews

The production of perennial crops involves planting, removal, yield, and time dimensions not similarly encountered in annual crops. A model is developed to provide a structural base for estimating response relationships that encompass these dimensions. The model rests on assumptions of rational producer behavior which takes account of possible actions of other producers and of the aggregate effect of these actions on total production and profits. Because important data series often are not available, modifications of the basic model are suggested to facilitate estimation within a more restricted empirical framework. The model is illustrated by an application to asparagus, a perennial vegetable crop.

In view of the rather extensive volume of literature pertaining to agricultural supply response, the special problems associated with formulating supply models for perennial crops have until very recently received surprisingly little attention.[1] Prior to 1960 there were almost no attempts to estimate such supply functions.[2] Some new ground was broken in a 1962 study by French and Bressler [14] which developed supply response for lemons in terms of new planting and removal relationships. This type of model development, with modifications or simplifications, was later applied by other researchers to United States apples [8], cherries [11], pears [24], and tung nuts [18], with varying success. Much of the recent research on perennial crop supply response has related to commodities typically produced in less developed areas—mainly coffee, cocoa, and rubber. Studies by Arak [2, 3], Bateman [4, 5], and Behrman [6] in particular have made significant advances in formulating perennial crop supply models, with special reference to these tropical or warm area commodities.

The purpose of this paper is to enlarge on the concepts utilized in the previous applied studies in order to broaden the analytical framework for measuring supply response for perennial crops.[3] Our model differs from the others mainly in its formulation of the framework within which new plantings and acreage adjustments are determined and in a more general specification of relationships that seem appropriate for most U.S.-produced perennial crops.[4] We also suggest modifications of the basic model which may enable the researcher to obtain some useful results within a more restricted empirical framework when important data series are lacking. The model is illustrated by an application to asparagus, a perennial vegetable crop.

The General Model

Perennial crop production is distinguished

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[1] Most issues of this Journal since the mid-1950's have contained articles that bear in some way on the measurement of supply response for annual crops and livestock. Many additional studies have been published as bulletins, books, or other research reports by state experiment stations and the U.S. Department of Agriculture. Among the more commonly cited references are Nerlove [20, 21] Nerlove and Bachman [22], and Heady et al. [16].

[2] We are aware of only two such studies during this period: a 1956 study by French [13], which developed a crude long-run supply function for apples, and a cocoa supply model by Ady [1]. The Ady study was later shown by Bateman [4] to be suspect.

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[3] Our focus, as in the studies above, is on models that may be estimated with time series data. Supply models for perennial crops using a linear programming approach have been developed by Dean and DeBenedictis [10] and Cingolani [9].

[4] The earlier studies by French and Bressler [14] and those immediately following were based on rather simple or limited behavioral assumptions and technical specifications. Among the more recent studies, Bateman [4, 5] considers several alternative conceptual models but assumes an infinite life for the perennial crop and thus does not deal with the removal aspect. The Arak model [2] is more complete in this respect but focuses heavily on the peculiarities of the Brazilian coffee industry. In work not yet published, models based on an alternative investment theory approach have met with mixed success. A study of the California-Arizona orange industry by Rausser [23] appears very promising. The final form of his model is similar in some respects to the one reported here but differs in data requirements and the use of distributed lags. Where relevant data can be obtained the Rausser model provides a basis for dealing with aspects of supply response, such as the effects of tax savings, ownership structure, and land appreciation. An investment behavior approach was also employed by Cingolani [9] in a study applied to oranges, grapes, and peaches. The statistical results obtained were generally unsatisfactory. A linear programming model for the same commodities and area provided somewhat more satisfactory results in the context of the particular study.

from the production of annual crops by (1) the long gestation period between initial input and first output, (2) an extended period of output flowing from the initial production or investment decision, and (3) eventually a gradual deterioration (usually) of the productive capacity of the plants. Thus, a perennial crop model must explain not only the planting process but the removal and replacement of plants and must explicitly consider the lags between input and output and the effects of populations of bearing plants on production.[5]

The orientation of our model is aggregative; that is, it attempts to explain the behavior of producers as a group, starting with certain assumptions about individual producer behavior. Producers are assumed to be faced with similar product and factor prices, to have similar production functions, and to attempt to maximize profits. We also assume that the behavior of individual producers is conditioned by expectations concerning the behavior of other producers and the probable impact of this behavior on output.[6] This point is developed further in the next section.

The model involves five major components: (1) a pair of functions that explain the quantity of production and bearing acreage desired by growers, (2) a new plantings function defined by the adjustments that would shift acreage toward the desired level, (3) an equation to explain acreage removed each year, (4) relationships between unobservable expectation variables and observable variables, and (5) an equation that explains variations in the values of average yields. An equation that explains year-to-year changes in acreage is obtained by combining (2) and (3). Total production is then determined by the identity that multiplies the acreage equation by the yield equation.

[5] Arak [2] considers an additional activity to be explained—abandonment. In view of the high value of alternative land uses relative to the cost of removal, this does not appear to be an important aspect of supply adjustment for most U. S. crops.

[6] Changes in the size and ownership structure of firms could influence the behavioral process. The model can be adapted to handle size changes through an explicit cost component but it takes no account of changes in ownership structure. If such structural changes were believed to be potentially important, it would be necessary to examine selected coefficients of the model for possible trend effects. The Rausser model referred to in footnote 4 has the potential to accommodate this problem through direct consideration of the ownership pattern and the associated tax structure. It also requires more data than are included in the present model.

Desired production and acreage

The form of the equation that explains changes in the quantity of total output desired by producers in the aggregate is derived from plausible assumptions about producer decision systems and the nature of cost and profit variation. The basic assumption is that the major variables influencing desired production are expected profitability of the commodity considered and expected profitability of alternative land uses. Expected profitability is a function of expected prices and costs. We shall for the moment defer discussion of the manner in which these expectations are formed and measured.

At any given time producers are assumed to have in mind a long-run "normal" or equilibrium rate of profitability per unit of output (π_t^*). Under competitive conditions, this implies an equilibrium price that would cover all costs plus "normal" profits. Each year producers form conditional long-run expectations about the average price likely to be obtained with expected normal yields (Y_t^e) and the current (previous year) level of bearing acreage (A_{t-1}). The expected average industry yield may vary with technology and the age composition of existing plants. From these conditional price expectations and their cost expectations, producers form conditional profit expectations (π_t^e).

Given their conditional and equilibrium profit expectations, producers attempt to adjust the level of average production (actual production may fluctuate from year to year because of random weather and biological factors) so as to achieve the long-run normal level of profitability. In a well-developed economy, the rate of adjustment to a given profit disequilibrium may be conditioned by producer awareness that other growers may hold conditional price and profit expectations similar to their own and that they may react in a similar manner. Each producer thus may have some notion (not necessarily correct) of the total change in production to be expected in association with any change he might make. He also may have some notion (not necessarily correct) of the effect of total production changes on prices and profitability. These notions determine how much desired production will be altered for any deviation between conditional and equilibrium profit expectations.

The adjustment process may be expressed as[7]

[7] Specification of a linear relationship is not essential to

$$(1) \qquad Q_t^* = Q_{t-1}^e + b_{11}(\pi_t^e - \pi_t^*) + b_{12}(\pi_{At}^e - \pi_{At}^*) + u_{1t}$$

where

Q_t^* = desired production for year t,

$Q_{t-1}^e = Y_{t-1}^e A_{t-1}$ = expected average production with acreage at the actual level of $t-1$,

π_t^e = expected long-run profitability per unit for the commodity of concern with production of Q_{t-1}^e,

π_t^* = normal long-run (equilibrium) profitability per unit of product for the commodity of concern,

π_{At}^e = conditional expected profitability per unit of product for the alternative land use,

π_{At}^* = normal long-run profitability per unit of product for the alternative land use, and

u_{1t} = a disturbance term.

For convenience we have specified only one alternative land use, but the model is easily extended to include more. The values of π_t^e and π_{At}^e are regarded as being determined independently. The value of b_{12} would be influenced by the expectations regarding supply adjustments for the alternative commodity or commodities.[8] We shall assume that these expectations follow a stable pattern so that b_{12} remains constant.

We would expect the sign of b_{11} to be positive and b_{12} to be negative. That is, positive deviations of the conditional profitability expectation from the equilibrium level would lead to desired production greater than the normal production with $t-1$ acreage. Positive deviations of the conditional expected profitability of the alternative, on the other hand, would reduce the current level of desired production, at least in the short run, as some producers would tend to shift some portion of their resources to the alternative.

Since the basic producer output decisions are implemented primarily in the form of acres planted and removed, we need an equation that explains changes in the quantity of bearing acres that producers desire to hold. This may be derived from (1) by noting that $Q_t^* = Y_t^e A_t^*$ and $Q_{t-1}^* = Y_{t-1}^e A_{t-1}$, where Y_t^e is expected normal or average yield, A_t^* is desired bearing acreage in year t and A_{t-1} is actual acreage in $t-1$. Substituting in (1) and rearranging terms, we obtain

$$(2) \qquad A_t^* = \frac{Y_{t-1}^e}{Y_t^e} A_{t-1} + \frac{b_{11}}{Y_t^e}(\pi_t^e - \pi_t^*) + \frac{b_{12}}{Y_t^e}(\pi_{At}^e - \pi_{At}^*) + \frac{u_{1t}}{Y_t^e}.$$

If expected yields remain constant or can be measured by a single observable variable, (2) leads to final statistical equations that can be estimated by ordinary regression methods, although the possible heteroskedasticity of the disturbance term with Y_t^e variable is bothersome. Conceivably, in the latter case u_{1t} in (1) could be somewhat proportional to Y_t^e, thus cancelling its effect in (2); but this is only one of many possibilities. More generally, if Y_t^e is expressed as some function of observable variables, (2) becomes quite messy for estimation purposes. In that case we may be forced, as a practical matter, to use some approximation of (2). A linear approximation could be derived by a Taylor series expansion of (2) around the mean values of A_t^*, A_{t-1}, Y_t^e, Y_{t-1}^e, dropping all expansion terms beyond the second. However, the coefficient structure obtained is somewhat cumbersome, so we have adopted a more convenient alternative which is also linear and which is similar to (2) for small changes in Y_t^e.

$$(3) \qquad A_t^* = A_{t-1} + b_{21}(\pi_t^e - \pi_t^*) + b_{22}(\pi_{At}^e - \pi_{At}^*) + b_{23}\Delta Y_t^e + u_{2t}$$

where

$$\Delta Y_t^e = Y_t^e - Y_{t-1}^e.$$

To accommodate the more general case (where Y_t^e is determined as some function of observable variables), we shall use (3) in the analysis that follows. Note that if $\pi_t^e = \pi_t^*$, $\pi_{At}^e = \pi_{At}^*$ and there is no change in expected yield, $A_t^* = A_{t-1} + u_{2t}$.

New plantings

Given the desired level of bearing acreage (A_t^*), desired new plantings (N_t^*) is the

the development that follows, and alternative forms could be substituted if it seemed appropriate. The linear form is more convenient to work with and is as plausible initially as any other.

[8] For example, the value of b_{12} might be small if it were expected that the disequilibrium for the alternative crop usually would be quickly reduced as a result of adjustments outside the commodity industry under consideration.

amount necessary to bring actual bearing acreage up to the desired level. The desired bearing acreage is, of course, not immediately achievable unless it is identical with acreage in $t-1$. It requires k years, where k is the interval between initial planting and classification as bearing. Thus, operationally, A_t^* may be replaced by A_{t+k}^* in (3). Desired new plantings then are determined by subtracting from A_{t+k}^* the actual bearing acreage in $t-1$ and all previous plantings which have yet to reach bearing age and adding the amount expected to be removed during the next k years, including year t. That is,

$$N_t^* = A_{t+k}^* - A_{t-1} + R_{kt}^e - N_{kt-1} \qquad (N_t^* \geq 0) \tag{4}$$

where

N_t^* = acreage of new plantings desired by growers in year t;

k = the interval of time in years between initial planting and classification as bearing;

R_{kt}^e = the total amount of acreage expected to be removed during the next k years, including year t;

$N_{kt-1} = \sum_{i=1}^{k} N_{t-i}$ = the total acreage planted after year $t-k-1$ (the nonbearing acreage as of $t-1$).

The value of R_{kt}^e involves two components: nonbearing and young and middle-aged bearing plants to be removed because of disease or insect damage and older plants removed because of declining productive capacity. Removals because of the former are likely to be proportional to the amount of bearing and nonbearing acreage. Removals because of declining productivity are likely to be highly correlated with and proportional to the acreage of plants exceeding the age at which productivity of the plants typically begins a significant decline.[9] Letting the latter be A^0, we obtain

$$\begin{aligned} R_{kt}^e &= b_{31}A_{t-1}^0 + b_{32}(N_{kt-1} + A_{t-1} - A_{t-1}^0) + u_{3t} \\ &= b_{33}A_{t-1}^0 + b_{32}N_{kt-1} + b_{32}A_{t-1} + u_{3t} \end{aligned} \tag{5}$$

where u_{3t} is a disturbance term, $0 \leq b_{31} \leq 1$, and b_{32} is a very small proportion.[10] The value of b_{32} conceivably could differ between nonbearing and middleaged bearing plants, but we shall treat it as constant since it is not, in general, a very important factor in any case.

Actual plantings (N_t) may differ from the desired plantings in a particular year because of frictions, rigidities, misjudgments, and the effects of combining actions of many producers. The model must specify the nature of such differences and therefore the nature of the relationship between actual and desired values. A plausible approach is to specify a partial adjustment relationship of the form[11]

$$N_t - \beta N_{t-1} = \alpha(N_t^* - \beta N_{t-1}) + e_t \tag{6}$$

which simplifies to

$$N_t = \alpha N_t^* + \beta(1-\alpha)N_{t-1} + e_t \tag{7}$$

where $0 < \alpha \leq 1$ is the "coefficient of adjustment" and $0 \leq \beta \leq 1$ is a term introduced to allow for some dampening of the residual effects of unattained past desired plantings.[12] Note that if $\beta = 1$, we have the commonly used Nerlove-type adjustment relationship (see [21]). If $\beta = 0$, failure to achieve a desired level of new plantings in one period will have no direct residual effect, in itself, on future plantings.

The assumptions that we may be able to make about the value of β may be quite stra-

[9] Conceivably, R_{kt}^e could also be affected by changes in price expectations. However, with removals ordinarily limited to the advanced age group (except for disease and insect or freeze damage), we would not expect changes in price expectations to greatly alter producer *expectations* as to total removals during the next k years.

[10] The disturbance term u_{3t} may be large and nonrandom if A_t^0 involves several age groups which vary substantially in their relative proportions. To illustrate, A_t^0 for asparagus might be defined as all acreage over 10 years of age. This could include asparagus beds of 11, 12, 13, 14, and 15 years. Large variations in the distribution within these age classes could affect the real value of b_{31}. Thus, it would be conceptually more proper to specify

$$R_{kt}^e = b_{31}A_{1t-1} + b_{32}A_{2t-1} + \cdots + b_{3r}A_{rt-1} + u_{3t}$$

where A_1 refers to acres (say) 11 years of age, A_2 = acres 12 years of age, and so on. As a practical matter, however, we normally cannot expect to be able to measure with this much detail.

[11] Bateman [5] suggests a model that uses farmer income of the previous year as a variable influencing the rate of adjustment between actual and desired plantings and therefore the level of actual plantings. We have not been able to introduce such a variable in the present model in a way that seems likely to be effective.

[12] Equation (7) may be solved to obtain a lag function of the form

$$N_t = \alpha N_t^* + \alpha \sum_{i=1}^{\infty} [\beta(1-\alpha)]^i N_{t-i}^* + \sum_{i=0}^{\infty} [\beta(1-\alpha)]^i e_{t-i}.$$

tegic in cases where data series on new plantings are not available. If we can reasonably assume that β is near zero, N_{t-1} drops out and, as will be demonstrated shortly, we may be able to eliminate N altogether as a variable in the final supply-response relationship.

For β to be zero, decisions must be implemented soon after they are made; i.e., plantings must depend only on decisions made during the current period. This requires that both capital and nursery stock be readily available or, if limited, will result only in $N_t \leq N_t^*$, with the inequality having no residual effects in future periods. The plausibility of these conditions clearly requires further examination.

Considering capital first, it seems very reasonable to expect the existence of capital restrictions to result in failure to equate N_t and N_t^*. The coefficient α in (7) reflects the potential dampening effects of occasional shortages of this type. Since desired plantings are reevaluated each period, depending on the current state of the system, there seems less reason to expect that past delays in capital acquisition will set in motion irreversible actions which would be imposed on current actions. While it is conceivable that unfulfilled past efforts at capital acquisition could affect the ease of acquiring capital in the current period (thus affecting N_t), we doubt that the impact would be very great in most cases.

In addition to capital the firm must be able to acquire young plants or trees for planting, and these ordinarily require about a year to produce. The lag problem involved may be handled by redefining the time of planting to coincide with the placing of an order for nursery stock and increasing the gestation period between planting and classification as bearing by one year. In this context, "placing an order" need not always involve formal contracts. Production of anticipation stocks by nurseries, based on informal surveys of growers regarding potential plantings, could be regarded as roughly equivalent actions. In these terms, initial implementation of a planting decision requires only the placing of an order, an action involving few restrictions.

Based on these arguments, we feel that the adjustment process represented by (7) with $\beta=0$ may be a reasonable approximation of conditions surrounding the production of many United States perennial crops. If new plantings data are available, this can of course be tested empirically. We shall assume that $\beta=0$ in the remainder of the present analysis. Note, however, that the model does permit failures to achieve desired levels of plantings to affect plantings in future periods, but it does so through the effect on N_k in (4).

The final new plantings equation now may be obtained by substituting (3) (with A_t^* replaced by A_{t+k}^*) and (5) into (4), (4) into (7) with $\beta=0$, and consolidating terms. This gives

$$\begin{aligned} N_t = {} & b_{51}(\pi_t^e - \pi_t^*) + b_{52}(\pi_{At}^e - \pi_{At}^*) \\ & + b_{53}\Delta Y_t^e + b_{54}A_{t-1}^0 + b_{55}N_{kt-1} \\ & + b_{56}A_{t-1} + u_{5t} \end{aligned} \tag{8}$$

where

$$\begin{aligned} b_{51} &= \alpha b_{21}, & b_{55} &= \alpha(b_{32-1}), \\ b_{52} &= \alpha b_{22}, & b_{56} &= \alpha b_{32}, \quad \text{and} \\ b_{53} &= \alpha b_{23}, & u_{5t} &= \alpha(u_{2t} + u_{3t}) + e_t. \\ b_{54} &= \alpha b_{33}, \end{aligned}$$

Acreage removed

In addition to the declining productivity considerations that influence *expected* removals, *actual* bearing acreage removed from production at the end of each year may be affected by (1) institutional and physical factors such as urban expansion or a heavy freeze, (2) short-run profit expectations for the next year (if high, some removals might be deferred; if low, removals might be accelerated), and (3) random factors associated with deviations between producer plans and actions. As with R_{kt}^e (expected removals over the future interval k), the portion of *annual* removals due to declining productivity seems likely to be highly correlated with the acreage exceeding the age at which productivity typically begins a significant decline. This may be measured most conveniently in the same way as was A^0 in equation (5). Actual acreage removed thus may be expressed as

$$\begin{aligned} R_t = {} & b_{60} + b_{61}A_t^0 + b_{62}A_t^0(\pi_t^s - \pi_t^*) \\ & + b_{63}A_t^0(\pi_{At}^s - \pi_{At}^*) + b_{64}Z_t \\ & + b_{65}A_t + u_{6t} \end{aligned} \tag{9}$$

where

R_t = acreage removed at the end of year (season) t,

A_t^0 = acreage over a particular age in year t,

π_t^s = short-run profit expections per

unit of product held in year t for year $t+1$,
π^{s}_{At} = short-run profit expectations per unit of product held in year t for the alternative land use in $t+1$,
π_t^*, π^*_{At} = long-run normal profitability per unit of product as of year t,
Z_t = variable to account for institutional or physical factors of importance,
A_t = bearing acreage in t, and
u_{6t} = a disturbance term.

The term A_t^0 enters as a cross-product in the expected profit terms since we would expect the rate at which removals could be adjusted to be roughly proportional to A_t^0. If A_t^0 were quite small, for example, little could be done to modify normal removals. It is possible that π_t^s and π_t^e (the long-run profitability expected to be associated with acreage A_{t-1}) could be measured identically, but they need not be. We would expect the signs of b_{61}, b_{63}, and b_{65} to be positive; b_{62} to be negative. The sign of b_{64} depends on the type of variable involved and its measurement. It would be positive for urban expansion or freeze variables.

Change in acreage

The total change in bearing acreage from one year to the next may be defined as

$$(10) \quad A_t - A_{t-1} = (1 - b_{32})N_{t-k} - R_{t-1} + v_{1t}$$

where k and b_{32} are as defined above and v_{1t} accounts for minor random variations in disease losses. Substituting (8) and (9) into (10) gives

$$
\begin{aligned}
& A_t - A_{t-1} \\
& = b_{70} + b_{71}(\pi^e_{t-k} - \pi^*_{t-k}) \\
& \quad + b_{72}(\pi^e_{At-k} - \pi^*_{At-k}) + b_{73}\Delta Y^e_{t-k} \\
& \quad + b_{74}A^0_{t-k-1} + b_{75}A^0_{t-1} \\
(11) \quad & \quad + b_{76}A^0_{t-1}(\pi^s_{t-1} - \pi^*_{t-1}) \\
& \quad + b_{77}A^0_{t-1}(\pi^s_{At-1} - \pi^*_{At-1}) \\
& \quad + b_{78}Z_{t-1} + b_{79}N_{kt-k-1} \\
& \quad + b_{710}A_{t-k-1} + b_{711}A_{t-1} + u_{7t}
\end{aligned}
$$

where

$$
\begin{aligned}
b_{70} &= -b_{60}, & b_{73} &= (1 - b_{32})b_{53}, \\
b_{71} &= (1 - b_{32})b_{51}, & b_{74} &= (1 - b_{32})b_{54}, \\
b_{72} &= (1 - b_{32})b_{52}, & b_{75} &= -b_{61}, \\
b_{76} &= -b_{62}, & b_{710} &= (1 - b_{32})b_{56}, \\
b_{77} &= -b_{63}, & b_{711} &= -b_{65}, \text{ and} \\
b_{78} &= -b_{64}, & u_{7t} &= (1 - b_{32})u_{5t-k} \\
b_{79} &= (1 - b_{32})b_{55}, & & \quad + u_{6t-1} + v_{1t}.
\end{aligned}
$$

Equation (11) indicates that the change in bearing acreage of a perennial crop from year $t-1$ to year t is determined by unit profit and yield expectations held in year $t-k$ (k=years to reach bearing age), by the acreage of "old age" plants in years $t-k-1$ and $t-1$, by short-run profit expectations held in $t-1$ (multiplied by old age acreage in $t-1$), by institutional factors or physical factors such as freezing weather (represented by Z), by the amount of nonbearing acreage as of $t-k-1$, by the total bearing acreage in $t-1$ and $t-k-1$, and by a random disturbance. We would expect b_{72}, b_{73}, b_{75}, b_{77}, b_{79}, and b_{711} to be negative; b_{71}, b_{74}, b_{76}, and b_{710} to be positive. The sign of b_{78} depends on the specification of Z. The coefficients b_{710} and b_{711}, which account for average disease and insect losses, would ordinarily be quite small. In view of the large number of variables in (11) and the possible intercorrelations, A_{t-k-1} and A_{t-1} might be deleted in empirical applications, with little loss.

Producer expectations

Equation (11) contains seven expectation variables (ΔY^e, π^*, π_A^*, π^e, π_A^e, π^s, and π_A^s) which have nonobservable values. Consequently, we must form hypotheses that relate the expectations to observable variables.

The expected change in average or normal yield seems likely to be closely related to the slope of a trend line fitted to recent yields of mature plants in full bearing. These expectations could be further modified by unusually rapid development of some new cultural practice or higher yielding variety and possibly by knowledge concerning likely changes in the age distribution of standing plants.[13] For discrete jumps in technical knowledge, a 0–1 variable might be used to shift the level of expectations. In general, the expected yield relationship may be specified as

[13] In the next section we show that actual average industry yields are a function of the age distribution of bearing plants. Ordinarily we would not expect the producer yield expectations to be so sophisticated as to project age cycles in average industry yields unless the age distribution was unusually skewed. Inability to do so, of course, may increase the deviations between desired and actual levels of production.

$$(12) \qquad \Delta Y_t^e = f(Y_{mt-1}, Y_{mt-2}, \cdots, v_{2t})$$

where Y_m refers to yields of plants at a mature bearing age. The specific form of (12) would be determined by empirical investigation in each case.

Profitability expectations present a similar, but somewhat more complex problem. Recall that π_t^e is the profitability per unit expected to prevail as long as bearing acreage remains at an A_{t-1} level. The long-run expectation, after allowing for acreage adjustments, is the equilibrium value π_t^*. In other words, the long-run predictions are essentially the predictions of economic theory and the adjustments are those that would move the acreage levels toward equilibrium values. The behavioral process thus appears similar to the type which Muth [19] refers to as "rational expectations."

Our first task is to define and measure π_t^*. Actual profitability per unit of product (π_t) is price less average cost ($P_t - C_t$). Under competitive conditions we would expect the long-run value of $P-C$ to be near zero except for "normal" profits. The conceived value of normal profit per unit could vary over time with the structure of the industry and possibly the level of average cost (particularly if cost levels vary mainly with general price levels). In the absence of some observable measures, π_t^* and π_{At}^* might be approximated as

$$(13) \qquad \pi_t^* = b_{80} + b_{81}C_t + u_{8t}$$

and

$$(14) \qquad \pi_{At}^* = b_{90} + b_{91}C_{At} + u_{9t}.$$

Average costs (C_t) may vary with technological changes, with changes in factor prices (determined outside the farming community), and possibly with the level of industry output. For most U. S. produced commodities, cost changes due to technological and exogenous factor price changes seem likely to greatly outweigh or even submerge the effects of changes in total industry output. Thus, it may be very difficult to detect the separate cost influence of changes in industry production. Moreover, for commodities that utilize only a small portion of suitable land resources, long-run average costs may remain virtually constant, except for the technological and outside factor price influences, over considerable ranges of total industry output. In these circumstances, it may be both practical and sensible to treat average cost as an exogenous variable. It is so treated in our application to asparagus supply.

If variations in industry output seem likely to have significant effects on average costs over the relevant range it would, of course, be necessary to develop functional relationships for this component. Since the parameters of this function are likely to be somewhat illusive and changeable, a synthetic approach or projections based on conditional simulations could prove more fruitful than attempted econometric estimation.[14] In any case, with C_t treated as an exogenous variable for estimation purposes, (13) and (14) may be used to substitute the observable C_t for the nonobservable π_t^* in (8), (9), and (11).

The discussion so far has implicitly assumed the existence of a time series of representative average production costs per unit of output. Unfortunately, such data often are not available. In these cases it still may be possible to obtain supply response estimates by regarding cost as a function of some index associated with cost changes, such as an index of wage rates. That situation is discussed more fully in the application section that follows.

The expected profit per unit (π_t^e) associated with acreage A_{t-1} might be the actual profit experienced in $t-1$. However, perennial crops typically are subject to fairly large year-to-year fluctuations in yields and production, so it is likely that producers might consider experience over several years as a better indicator of expected profitability. This indicator might be summarized in the form of a simple average, or it could follow some more complex form such as would be derived from a Nerlove-type adaptive expectations model [20 and 21]. In some cases a synthetic variable (L_t) might be added to allow for temporary modification of π_t^e as a consequence of an unusual event such as the termination of the Bracero Program which rather suddenly altered sources of labor supplies. A method of measuring L_t is illustrated in the application section. With these considerations the expected profit functions may be specified generally as

$$(15) \qquad \pi_t^e = h(\pi_{t-1}, \pi_{t-2}, \cdots, L_t, v_{3t})$$

and

$$(16) \qquad \pi_{At}^e = h_A(\pi_{At-1}, \pi_{At-2}, \cdots, v_{4t})$$

[14] For an example of a simulation approach which evaluates conditional changes in industry cost levels, see [15].

where the specific forms are determined by empirical investigation in each case. Our limited experience suggests that simple averages of past profit indicators may perform as well or better, in the context of this model, than a more complex weighting structure.

The short-run profit expectations for year $t+1$, (π_t^s and π_{At}^s), might be determined in a manner similar to (15) and (16). It is also reasonable to suppose that the most recent experience might be given maximum weight, with π_t^s determined approximately as $\pi_t^s=\pi_t$. This again is a matter to be determined by empirical investigation in each specific study.[15]

Yield relationship

The per acre yield of a perennial crop varies with the age of the bearing plants, with technology (cultural techniques, varieties, etc.) and weather and biological factors. In some cases, current yields also may be related to past yields by alternate bearing tendencies and conceivably may be varied in response to current profit expectations, primarily by more complete and careful harvesting practices. We shall disregard the last two factors in the development that follows since alternate bearing is by no means universal and most cultural practices appear to be so standardized as to preclude much variation in yield in response to profit expectations. Where such factors are thought to be important they are easily added to the yield function.

The effects of technological changes may be measured by a trend variable (function of time or by dummy variables). The effects of weather and biological factors typically are represented as random disturbances. Thus the average industry yield function may be expressed as

$$Y_t = \sum_{i=k}^{H} a_i A_{it} + b_{71} T + v_{5t} \tag{17}$$

where

A_{it} = the acreage of the ith age in year t,
k = the initial bearing age,
H = a reasonable maximum age of the plant,
T = time, and
v_{5t} = a disturbance term.

[15] Institutional factors, such as the termination of the Bracero program mentioned earlier, could also influence either or both short- and long-run profit expectations. If considered important, variables to account for these factors would have to be introduced into the expected profit functions.

For plants that live for very long periods it is clear that (17) may involve many variables—in fact, probably more variables than degrees of freedom. As a practical matter, however, it is not necessary to deal with the complete distribution of ages since there is typically a long period in the life cycle in which average yield remains about level. Plantings thus may be grouped into three or four classes with each group represented by a different average yield. For example, assuming plants start to bear at age 5, group 1 might be plants 5–9 years of age; group 2, plants 10–29 years; and group 3, all plants 30 and over. Equation (17) would then become

$$\begin{aligned} Y_t = a_{10} + a_{11} A_{1t} + a_{12} A_{2t} + a_{13} A_{3t} \\ + a_{14} T + v_{6t}. \end{aligned} \tag{18}$$

If the time series data pertaining to age distribution can be obtained, (18) provides a reasonable type of model for estimating the yield relationship. To be useful as a tool for internally derived future predictions, however, the model must also generate annual values of the A_i's. The model generates values of acres planted and removed each year, but to determine the age distribution it is also necessary to determine the proportion (r) of young and middle-aged bearing plants removed each year because of disease loss or similar causes.

Referring to (5) and (10), r may be specified as $b_{32} \div k$, where b_{32} is the proportion of plants removed because of disease and insect damage during the gestation interval k. Depending on the estimating procedure used, b_{32} (and, therefore, r) may be difficult to identify in the estimates of the model parameters as developed previously. Where the data can be obtained, r may be estimated from successive observations on the age distribution of standing plants.[16] The acreage falling into each age class then may be readily determined.[17]

[16] Continuous series on age distributions of perennial crops are not widely available. However, the California Statistical Reporting Service compiles such data for a number of perennial crops.

[17] Using the three bearing age groups given in the example above, the acreage in each class may be adjusted annually by the following set of equations:

(a) $A_{1t} = (1-r)A_{1t-1} + (1-r)^k N_{t-k} - (1-r)^{k+5} N_{t-10}$,

(b) $A_{2t} = (1-r)A_{2t-1} + (1-r)^{k+5} N_{t-10} - (1-r)^{k+25} N_{t-30}$,

(c) $A_{3t} = A_{3t-1} + (1-r)^{k+25} N_{t-30} - [R_t - r(A_{1t-1} + A_{2t-1})]$,

where k is the time interval between planting and bearing age (5 in this example). Group 1 would include all plants

Where data pertaining to age distribution are not available there is little that the researcher can do other than measure yields as some function of time, taking care that variations due to an age cycle are not projected as trends. This may not be a serious problem for perennial crops that live for long periods so that the average yield does not vary substantially with age distribution. In some cases yield predictions may be improved by utilizing information on past changes in bearing acreage. For example, a recent expansion of acreage may be associated with an increased proportion of plants in the young bearing age group which typically have lower yields, thus reducing the average industry yield. The information content of more distant past acreage changes is likely to be more difficult to extract because of the cumulative effects of many earlier actions and the very long data series required for measurement purposes. Thus (18) might be approximated by

$$(19) \quad Y_t = a_{20} + a_{21}(A_t - A_{t-h}) + a_{22}T + v_{7t}$$

where h is a small number such as 2, 3, or 4.

Estimation of the Model Parameters

By substituting (12), (13), (14), (15), and (16) in (8) we obtain a new plantings equation in which the variables on the right are all predetermined with respect to N_t. Similarly, by specifying a relationship between π_t^* and an observable variable, such as $\pi_t^* = \pi_t$, acreage removed (equation (9)) may be expressed as a function only of predetermined variables. If we can reasonably assume the disturbance terms to be random variables with mean zero and constant variance, the parameters of these equations may be estimated by ordinary least squares. However, the disturbance terms of these equations (u_5 plus linear components of v_2, u_8, u_0, v_3 and v_4 in (8) and similar components in (9)) are quite complex Thus, the initial specification must be examined and tested in each empirical application.

Estimates of the parameters of (11) may be derived from the parameter estimates of (8) and (9), provided $(1-b_{32})$, the proportion of new plantings which survive to bearing age, can be estimated. The latter appears unidentified as a part of b_{55} in (8) and implicitly in (9). However, it may be estimated from data series on the age distribution of standing plants, as indicated for r in the previous section.

The yield relationship may also be estimated by ordinary least squares, as suggested by (18) or (19). Adding the identity equation $Q_t = A_t Y_t$ completes the statistical estimation of the supply response system.

Perhaps the major problem involved in estimating supply response systems for perennial crops is the limited availability of data pertaining to new plantings, acreage removed, and the age distribution of standing plants. Where planting and removal data are lacking, the parameters of (11), the acreage adjustment equation, may be estimated directly after substituting the appropriate expectation functions. The major disadvantage of estimating (11) directly is that it involves more variables and therefore fewer degrees of freedom than (8) and (9).[18] There is also a loss of information about plantings and removals.

The disturbance term of (11), (u_{7t}), which at first glance may appear to involve a type of serial correlation will on closer inspection be revealed to be serially uncorrelated if u_5 and u_6 are not serially correlated and all other disturbances are independently distributed. Although the disturbance arises from past events, it is not correlated with its own past values. Substituting (12), (13), (14), (15), and (16) in (11) would not appear to alter this.

A final data problem of importance is the possible lack of information regarding A^0, the acreage in the "old age" class. Where such data are not available it is necessary to seek some means of approximating the variable. The approach to this problem is best discussed in the context of the empirical illustration of the model, which is presented next.

Supply Response for Asparagus

Asparagus is a perennial vegetable crop with a productive life of 10 to 15 years. Asparagus crowns planted in year t are classed as harvested

planted during $t-9$ to $t-k$; group 2, all plants planted during $t-29$ to $t-10$; and group 3, all plants planted in $t-30$ or before. The acreage in group 1 in year t is equal to the group 1 acreage in $t-1$ (reduced by disease losses) plus plantings reaching bearing age, also reduced by disease losses, less plants which shift to the next age class, again reduced by disease loss. Equation (b) is interpreted in a similar manner. The last term of (c) subtracts from A_3 all acreage removed from production R_t less the amounts of groups 1 and 2 removed because of disease loss.

[18] Recall that we suggested earlier that A_{t-1} and A_{t-k-1} might be deleted from (11) with little loss. This is less true of other variables, although in some cases it may be necessary to delete N_{t-k-1} simply because the data are not available, with a consequent loss of efficiency.

acreage in year $t+2$, although the initial cutting period is short and the yields small. The crowns in turn require one year to produce [25]. Thus, a period of two to three years may elapse between the time of initial decision to plant asparagus and the resulting change in harvested acreage, the length depending on the seasonal timing of the decision and how quickly the grower can obtain or grow crowns.

As part of a broader study of the U. S. asparagus industry we have estimated supply response equations for each of three U. S. producing areas: California, the Midwest-East, and the Northwest.[19] Relevant data available for each region consist of harvested acres (bearing acres), yields, and prices received by growers. There are no continuous series on costs of production and, with the exception of California, no data on plantings, removals, and age distribution of plants. Because of both actual and suspected limitations we also chose not to use the California data.[20] Consequently, it was necessary to turn to the acreage change equation (11) as the structural base for our model estimation.

Three simplifications were introduced into (11) at the outset. First, average yields of mature acreages of asparagus appear not to have varied much over the period of analysis (1947 to 1969). Therefore, ΔY^e becomes zero and is deleted.[21] Second, the term N_{kt-k-1} was deleted simply because data pertaining to nonbearing acres are not published (with a partial exception for California; see footnote 20). The effect thus is included in the disturbance term. Finally, since the alternatives to asparagus production vary rather widely among farms, no meaningful measures of π_A^e could be developed and this term was deleted. The summary effects of alternative profit possibilities appear as part of the disturbance term and add to the variance of our estimates.

Since continuous data series pertaining to costs of producing asparagus are not available, it was necessary to develop some alternative means of approximating the profitability variable π_t. We specified simply that

$$\pi_t^e = c_0 + c_1\left(\frac{P_t}{W_t}\right)^e + v_{8t} \tag{20}$$

where P_t is the grower price, W_t is an index of farm wage rates expressed as a proportion, and the superscript e denotes an expected value. The importance and visibility of labor cost in asparagus production suggests that this measure may be highly correlated with grower cost and profit expectations.[22]

We assume there exists some value of $(P_t/W_t)^e$ such that $\pi_t^e = \pi_t^*$. Thus,

$$\begin{aligned}\pi_t^* &= c_0 + c_1\left(\frac{P}{W}\right)^* + v_{8t} \\ &= c_2 + v_{8t} \qquad \text{for all } t\end{aligned} \tag{21}$$

and we are left with only $(P_t/W_t)^e$ as a variable factor. The value of $(P_t/W_t)^e$ is approximated as a two-year average of actual values of P_t/W_t. We also considered an alternative specification which expressed $(P_t/W_t)^e$ as a geometrically weighted average of past prices.[23] Several values of the adjustment coefficient were tested but in all cases the simple two-year average proved statistically superior.

The expected profitability in $t+1$ (π_t^e) was measured in a similar manner except that we specified $(P_t/W_t)^e = P_t/W_t$. As an alternative specification, we also measured $(P_t/W_t)^e$ as an average of P_t/W_t and P_{t-1}/W_{t-1}. However, the

[19] We would have preferred to treat the Midwest and East separately, but were precluded from doing so by the grouping of state production data in the U. S. Department of Agriculture statistical reports. The principal producing states in the East are New Jersey, Maryland, and Delaware; in the Midwest, Michigan and Illinois. The USDA crop data group other states in both regions into a single "Other States" category, thus preventing a clear geographical tabulation; see [22].

[20] The California Asparagus Growers Association annually conducts acreage surveys which tabulate plantings and plow-outs for the northern part of the state only. In reviewing the data we found inconsistencies in some years, which suggested caution in its use. Statistical exploration with these limited data, along the lines suggested by equations (8) and (9), did, however, give results consistent with our hypotheses.

[21] Actual yields have varied cyclically, apparently because of the cycling of the age distribution of acreage (see the previous section). This, however, is believed not to influence expected yields.

[22] The wage rate index is based on the USDA composite farm wage rate [26]. For grower price and acreage data see [27].

[23] This formulation is derived from the adaptive expectations model; see Nerlove [20]. More specifically, conditional expected profitability was specified as

$$\left(\frac{P_t}{W_t}\right)^e = B\left(\frac{P_{t-1}}{W_{t-1}}\right) + (1-B)B\left(\frac{P_{t-2}}{W_{t-2}}\right) + (1-B)^2B\left(\frac{P_{t-3}}{W_{t-3}}\right) + \cdots .$$

The supply model was estimated for alternative values of B ranging from .8 to .4, lagged back to $t-4$.

single year proved generally more significant, suggesting that growers may make very short-run projections on the basis of only the most recent experience.

Although A^0 (acreage of old asparagus) is technically observable, we have no data to measure it (at least not accurately). Therefore, we were forced to seek some closely associated variable that could be substituted. This seems likely to be a fairly common problem in measuring supply response for perennial crops and success in this regard will have much to do with the quality of the empirical model.

A possible procedure is to let old age acreage be proportional to total acreage ($A_t^0=\alpha_1 A_t$). This may be a reasonably good approximation during periods when acreage has remained fairly stable. During periods when acreage is increasing, however, it may overstate the proportion of older age acreage since expansion requires that new acreage be added faster than old acreage is removed. Similarly, during periods of declining acreage, new plantings are not keeping up with removals and the proportions of acreage in the higher age classes may be larger. To account in part for this, we have specified that $A_t^0=\alpha_2\overline{A}_t+v_{9t}$, where $\overline{A}_t$ is the average harvested acreage during the previous five years, v_{9t} is an error term which accounts for random variation in the relationship, and α_2 is a constant less than one. Again, this type of modification adds to the stochastic term of the model, but it seems reasonable as an approximation.

There is a final institutional factor to be considered. In 1964 the U. S. Congress repealed P.L. 78, the Mexican National Farm Labor Program, commonly referred to as the Bracero program. This sharp alteration in the source of asparagus harvest labor had a great, although temporary, psychological effect on growers, leading to short-term adjustments in profit expectations and to unusually large removals of acreage in 1965. To allow for this event we introduced a synthetic variable, L, where $L=0$ prior to 1965, 1.000 in 1965, 0.500 in 1966, 0.250 in 1967, 0.125 in 1968, and 0 again in 1969. This permits the initial shock to dissipate approximately as a decay curve.

With these specifications, the supply equation to be estimated takes the form

$$
\begin{aligned}
A_t - A_{t-1} &= B_0 + B_1 P_{1t-1}\overline{A}_{t-1} \\
&\quad + B_2 P_{2t-k-1} + B_3\overline{A}_{t-1} \\
&\quad + B_4\overline{A}_{t-k-1} + B_5 L_t + s_t
\end{aligned}
\tag{22}
$$

where $P_{1t-1}=P_{t-1}/W_{t-1}$, $P_{2t-k-1}=\frac{1}{2}(P_{1t-k-1}+P_{1t-k-2})$, and s_t is a disturbance term. The substitution of $\overline{A}$ for A^0 in the second term suggests that s_t could be correlated with the size of P_{1t-1}, but we would expect the effect to be a minor part of the generating process for s_t.[24] Since nonbearing periods of either $k=2$ or $k=3$ could be consistent with our behavioral hypothesis, depending on how quickly producers were able to transform profit expectations into actual plantings, we estimated equations based on both values. For California and the Midwest-East, $k=2$ gave substantially better statistical results; while for the Northwest, $k=3$ proved slightly superior. Ordinary least squares estimates of (22) using the best values of k are summarized in Table 1.

The estimates for California and the Midwest-East are generally quite good. The signs of all coefficients are consistent with our expectations and, with one exception, are all large relative to their standard errors.[25] Note that the coefficient of L_t, the synthetic variable which allows for the effect of the termination of the Bracero program is quite significant in both regions but much larger for California. It was not significant at all in the Northwest and so was dropped from that equation. This, again, is consistent with our conjecture, since California growers relied much more heavily on the imported labor.

The supply response estimates for the Northwest, although consistent with our basic structural hypotheses, were considerably less satisfactory than for the other regions. There appear to be two major reasons for this. First, the acreage was relatively small and was increasing throughout much of the period of the study. Therefore there was a limited amount of acreage to be removed each year so the current price variable ($P_{1t-1}\overline{A}_{t-1}$) could not have much effect. In fact, including this variable produced a spurious negative coefficient since its correlation with other independent variables inter-

[24] This, of course, violates the assumptions of the general linear regression model which specifies all predetermined variables to be independent of the stochastic term. This implies that ordinary least squares estimates are inefficient. In empirical work, however, our concern is not that these assumptions are precisely fulfilled, but the degree of approximation. We argue that here it is good.

[25] As would be expected, $\overline{A}_{t-1}$ and $\overline{A}_{t-k-1}$ were positively correlated, with $r=.83$. This was not sufficiently high to cause major problems. The coefficients of these variables were consistent with a priori expectations and generally large relative to their standard errors.

Table 1. Regional acreage response equations for asparagus[a] (dependent variable is $A_t - A_{t-1}$)

Region	Constant term	Explanatory variables						R^2	d[e]
		$P_{1t-1}\bar{A}_{t-1}$[b]	P_{2t-k-1}[c]	$\bar{A}_{t-1}$	$\bar{A}_{t-k-1}$[d]	L_t	M_t		
		Regression coefficients							
California	−78.7324	0.02279 (0.00571)[f]	3.13764 (0.53584)	−0.51034 (0.16465)	0.76783 (0.25261)	−8.15962 (1.78065)		.856	2.40
Midwest-East	−18.2433	0.00331 (0.00524)	1.22065 (0.25970)	−0.35688 (0.10458)	0.36334 (0.12945)	−1.83565 (0.84767)		.875	2.98
Northwest	− 2.53569		0.27580 (0.10351)	−0.15371 (0.11917)	0.14165 (0.11913)		1.44383 (0.31331)	.715	2.51

[a] Based on data covering the period 1947 to 1969. The first observation on the dependent variable is 1951. Acres are measured in 1000's and price in cents per pound. The index of wage rates is expressed as a proportion.
[b] $P_{1t-1} = P_{t-1}/W_{t-1}$.
[c] $P_{2t-k-1} = 1/2(P_{1t-k-1} + P_{1t-k-2})$. For California and the Midwest–East, $k=2$; for the Northwest, $k=3$.
[d] See footnote [c].
[e] Durbin-Watson statistic. All values fall in the inconclusive range—see [12].
[f] Figures in parentheses are standard errors.

ferred with their effects. Consequently the variable was omitted.

A second problem associated with the relatively small Northwest acreage (ranging from about 1/5 to 1/3 the amount in the other two regions) was the relatively much greater impact of unusual events. In 1957 and 1958 there were large increases in acreage which do not appear to be closely related to previous measures of profitability or to our average acreage variable. Associated with this change could have been an event such as new land development or a large company operation, but our investigation was not able to ascertain this. Rather than let these two observations bias the total results, however, we introduced a dummy variable M to allow the level of supply response to shift in these two years. While not recommended as a general procedure, it seemed the best of the available alternatives in this case. Had we been able to obtain measures of new plantings and removals—and especially measures of A^0 rather than the proxy $\bar{A}$—it is possible that our results here might have been much better.

Yield relationships, estimated as suggested by equation (19) with $h=4$, are summarized in Table 2. Since new plantings of asparagus typically have quite low yields, inclusion of the recent change in harvested acreage significantly improves the yield prediction, with the sign of the coefficient in accordance with expectations. The positive trend coefficient for California is consistent with our general expectations about trends in yields; i.e., they are usually upward. The seemingly contrary trend coefficients for the Northwest and Midwest-East appear to reflect in considerable part a measurement problem associated with a shift from cutting to more snapping and changing farm level spear length. These trends therefore should be viewed only as short-run movements for the period of the statistical analysis and not be taken as indicators of longer-term shifts.

To obtain predicted supply adjustments in each region, the acreage predictions of (22) in Table 1 are multiplied by the yield predictions of (19) in Table 2. For projection purposes it would of course be necessary to further modify the trend coefficients of the yield equations.

Table 2. Yield relationships for asparagus, 1947-1969[a] (dependent variable is yield per acre)[b]

Region	Constant term	Explanatory variables		R^2	d[e]	$S_{y.x}$[f]
		$A_t - A_{t-4}$[c]	T[d]			
		Regression coefficients				
California	2.28868	−0.02006 (0.01054)[g]	0.02989 (0.01639)	.806	1.96	0.17425
Midwest-East	2.44466	−0.01860 (0.00654)	−0.03618 (0.00671)	.684	1.48	0.09745
Northwest	3.23450	−0.11000 (0.02633)	−0.01622 (0.00878)	.545	1.62	0.20778

[a] First observation is 1951.
[b] Yield per acre (Y_t) is measured in 1,000 pounds.
[c] A_t is harvested acres in year t in 1,000's.
[d] T is time, 1951=1.
[e] Durbin-Watson statistic. The hypothesis of serially correlated residuals is rejected at the five percent level of significance in all cases—see [12].
[f] Root mean square of the residuals.
[g] Figures in parentheses are standard errors.

Conclusions

In spite of the difficulties with our estimates of acreage response for the Northwest we feel encouraged by the overall results. The model, based on simple assumptions of rational behavior, provides a framework for estimating the differential rates of supply expansion and contraction for perennial crops and brings out explicitly the nature of the variables and the gestation lags involved. The need for better data pertaining to plantings, removals, and age distribution in order to develop improved estimates of supply response for perennial crops is quite apparent. Although forced to delete some unobtainable variables, we have been able to modify the basic model so as to utilize the kinds of information typically available. The values obtained in our application to asparagus production are consistent with our behavioral hypotheses and indicate that it is possible to develop meaningful supply response relationships for perennial crops in circumstances where our data are far less complete than we would like.

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On Multistage Multiproduct Production Functions*

YAIR MUNDLAK AND ASSAF RAZIN

To avoid the problem of product aggregation, the production process is formulated as $F(a) = G(v)$ where a and v are vectors of products and factors respectively. $F(a)$ is further specified as a multistage CES function and estimated by using the first-order conditions and duality relations. Some general questions of judging the results and the adequacy of grouping are discussed.

1. Introduction

THE USUAL procedure of product aggregation in the measurement of productivity results in a production function whose dependent variable is value product evaluated at constant prices. This procedure ignores the fact that with given resources various combinations of the products in question, as described by the transformation curve, can be produced. It is this limitation that this paper attempts to remove. However, this is not the only difficulty of a description of the production process which consists of a product component as the dependent variable and a factor component as an independent variable. In the following section it is shown that if the individual products are disjoint in the sense that they can be described by independent production functions, then the aggregate function cannot generally be decomposed into separable product and factor components. This difficulty is ignored here. If on the other hand there exists a joint production, then it is accommodated by the present formulation. This discussion provides a perspective for analysis such as that conducted here. The reader interested only in the results may start with section 3.

The function used in this paper is a generalization of the CES function of the form presented by Sato [10]. It is described in section 3. The product component of the function is estimated using data for Israel agriculture for the period 1954–1968. The results are presented in section 4.

A major problem is how to determine whether the results are reasonable in some sense. First, once the product component of the function is estimated, it is possible to compute the price of such an aggregate by using duality relations in production. Having the aggregate output and its price, their product gives a computed total revenue. This is compared with actual revenue and a close agreement is obtained. In some sense, this procedure resembles in nature a measure of goodness of fit such as R^2. Second, the particular function used assumes strong separability. This property facilitates a simple estimation procedure. However, at the same time separability imposes some other conditions that have to be met which amount to the fact that the same parameters can be estimated from more than one equation. This question is discussed briefly in section 5. Section 6 deals with some empirical considerations in the process of grouping.

Once estimates of the function are obtained, they can be used for evaluating quantitatively various questions of index numbers and aggregate measures of technical change. This was done in [7] where preliminary estimates of the same function were used; thus that discussion can be viewed as supplementing the present paper.

2. Description of the Technology

The basic approach used in this work is to seek a simple description of the technology open to the economy or to a given sector. The starting formulation is of the general form:

$$H(a, v) = 0 \tag{2.1}$$

where a and v are vectors of products and of factors, respectively.

A description of the technology by a single function provides a convenient tool for analysis. Given (2.1), supply of resources, and demand for products, most economic questions with respect to the particular economic unit can be answered. In particular we can evaluate the response of the economy to exogenous changes in either demand for products or factor supply.

The question is whether the production

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function (2.1) does at all exist. Certainly, there are production processes, such as joint production, that are completely specified by (2.1). The question then refers to cases where the production process is described by an individual production function for each product such as:

$$a_i = h^i(v^i) \quad i = 1, \cdots, I \tag{2.2}$$

where $v^i = (v_{1i}, \cdots, v_{mi})'$ is the vector of inputs used in the production of a_i. That is, v_{ij} is the input of the jth factor allocated to the ith product.

Before investigating the relationships between (2.2) and (2.1) it should be noted that the estimation of (2.2) requires data on factor allocation among products whereas the estimation of (2.1) requires only data on total inputs. Usually, the data on factor allocation are not available, which may partly explain the fact that the usual procedure is to estimate an aggregate production function in which the dependent variable is output evaluated at constant prices or some index number representing a change in value output. Such a procedure of course does not constitute a proof that what is estimated is actually a function; it is only a description of a common practice in empirical analysis.

To explore the existence and some properties of (2.1) under the assumption that production is completely specified by (2.2), we deal here with the known two-product two-factor case. In this analysis we assume that the two production functions are homogeneous of degree 1 and properly behave in the sense that marginal productivities are always positive and ever diminishing. Under such assumptions, the contract curve, in an Edgeworth Box Diagram transformed to the product space, yields a transformation curve with the known properties. Let the total amount of the two factors be v_1 and v_2 and the outputs of the two products be a_1 and a_2. It is convenient to draw the transformation curve as in Figure 1 where the axes are outputs divided by the total amount of the first factor. We refer to those as per capita outputs. Given p, the product price ratio, a tangency solution is immediately obtained. Let it be S (Figure 1). In view of the first degree homogeneity of the individual production functions the transformation curve in terms of per capita outputs is uniquely determined by the factor ratio v_2/v_1. So we may write

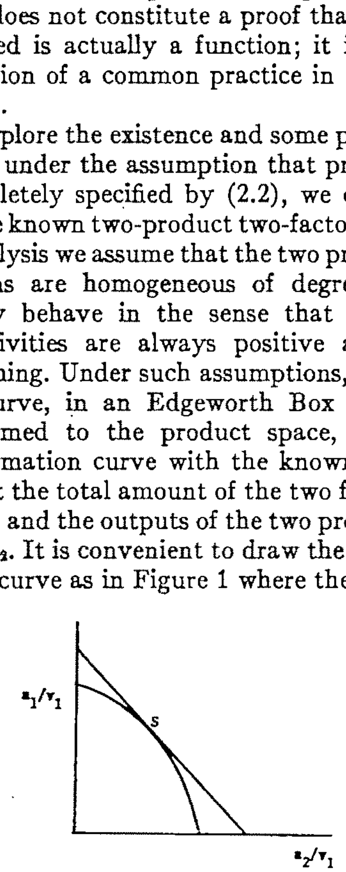

Figure 1

$$\begin{aligned} a_1/v_1 &= f^1(.) \qquad (.) = (p, k),\ k = v_2/v_1 \\ a_2/v_1 &= f^2(.) \end{aligned} \tag{2.3}$$

or written as a vector function:

$$a/v_1 = f(.) \tag{2.4}$$

where

$$a = (a_1, a_2)' \quad \text{and} \quad f(.) = [f^1(.), f^2(.)]'$$

But from the construction it is clear that at any point

$$a = v_1 f(p, k) = g(p, v_1, v_2) \tag{2.5}$$

where clearly (2.5) indicates that g is homogeneous of the first degree in v_1 and v_2. This is simply a restatement of the fact that the transformation curve of per capita outputs is only a function of the ratio k.

By varying p and holding v_1 and v_2 constant we trace the transformation curve whose slope at any point a depends only on the factor ratio k. So the general expression for the production function can now be written as

$$F_{(k)}(a_1, a_2) = G(v_1, v_2) \tag{2.6}$$

The function $G(v_1, v_2)$ is a measure of aggregate input which determines the production possibilities of a_1 and a_2 as given by $F_{(k)}$. That is to say, various values of v_1 and v_2 which result in the same value for $G(v_1, v_2)$ will result in a change in k and therefore will give different transformation curves. This result is in fact connected with the Rybczynski Theorem [8] in the theory of international trade, which states that at a given product price ratio an increase in the total amount of one factor leads to an absolute increase in the output of the product that is intensive in this factor and to an absolute decline in the output of the other product. In terms of the foregoing discussion we can apply this theorem twice: (1) increase v_2, the result being an increase in the output of the product that is intensive in v_2, say a_2 and a decline in a_1; (2) decrease v_1 to compensate for the increase in v_2 so that G will remain constant.

The outcome reinforces the result in (1) above. Figure 2 illustrates such a change where an increase in v_2 and a decrease in v_1 lead to a movement from S to M which are found on different transformation curves. The generalization to many products and many factors is straightforward. We have thus established the transformation of the system given in (2.2) into (2.6), which is a specific formulation of (2.1). The only sacrifice in information that results from working with (2.1) rather than with (2.2) is that (2.1) does not allow us to determine the allocation of the factors among the products. This of course, may be of some interest. However, if this is the case, such an interest is expected to yield data on factor allocation among products so that if one desires he can also estimate (2.2).

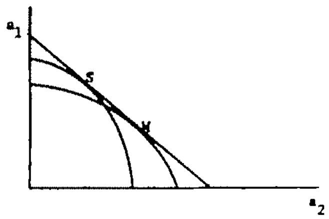

Figure 2

The foregoing discussion is based on the assumption that (2.2) is a detailed description of the technology whereas (2.1) is a summary description. However, in the presence of joint production the system (2.2) is not a correct description of the technology. On the other hand, (2.1) accommodates joint production and thus remains a correct description. The relevance of this depends on the question whether joint production does at all exist. This of course is an empirical question. One way to test it is to estimate empirically a modified version of (2.2):

$$(2.7) \quad a_1 = h^1(v_{11}, \cdots, v_{m1}, a_2, \cdots, a_l)$$

and similarly for the other products.

If the empirical test shows that (2.7) does not reduce to (2.2), it is evident that there is joint production. Since in our particular case we have no data on resource allocation, this test has not been pursued. However, to accommodate for joint production one has to select an appropriate functional form for the transformation curve. This subject is discussed by Samuelson [9]. Without going into details it suffices to indicate that the particular form analyzed in this paper is an appropriate one for the case of joint production.

3. The Function

The functional form that we use is of the ACMS type [1], consisting of several stages along the lines used by Sato [10]. Before giving a general description we take up a simple representation for the two-product two-factor case. So an algebraic formulation of (2.6) takes the form:

$$(3.1) \quad (A_1a_1^\rho + A_2(k)a_2^\rho)^{1/\rho} = (\beta_1K^\delta + \beta_2L^\delta)^{1/\delta} \equiv G(v);\delta \le 1 \le \rho.$$

The right-hand side of (3.1) is the usual ACMS-like formulation of the factor side. The left-hand side is a similar formulation for the product side. Note that A_2 is written as a function of the factor ratio k. At this point we simplify the function by imposing a constant A_2. That is, we ignore the dependence of the transformation curve on the factor ratio. This of course constitutes a departure from the general formulation. Yet this departure is still not as serious as the common practice where output is evaluated at constant prices. In that case, the left-hand side of (3.1) is replaced by the expression

$$(3.2) \quad P_1(0)a_1(t) + p_2(0)a_2(t)$$

where $P_i(0)$ is the price of a_i at some base period whereas $a_i(t)$ is the output in period t. Clearly (3.2) is a special case of the left-hand side of (3.1) obtained by setting $\rho = 1$, $A_1 = P_1(0)$ and $A_2 = P_2(0)$ and both A_1 and A_2 are constants. So our procedure constitutes a generalization of the common procedure.

We turn now to an extension of the left-hand side of (3.1) to include more products, and we do it under the assumptions that all the A_i coefficients are independent of factor ratios. Before presenting the functional form, we note that the direct elasticity of substitution (DES) between a_1 and a_2 derived from (3.1) is [2]: $DES_{a1/a2} = 1/(1-\rho)$. There is no reason to assume that the DES is the same for all products. To allow for different DES for various pairs of products we adopt the framework of Sato [10] to get the multistage function.

Let there be A products. The output of the α product is denoted by a_α. In the first stage of aggregation (stage α), the A products are grouped into B disjoint and exhaustive groups. A function b_β is defined on each of these groups. The B functions b_β are grouped into Γ disjoint

and exhaustive groups, and new functions c_γ are defined on these groups. This process continues until a final aggregate function results. So we get:

Stage Alpha

$$b_\beta = \left(\sum_{\alpha \in b\beta} A_\alpha a_\alpha^{\rho_\beta} \right)^{1/\rho_\beta} \tag{3.3}$$

$$\beta = 1, \cdots, B$$

Stage Beta

$$c_\gamma = \left(\sum_{\beta \in c\gamma} B_\beta b_\beta^{\rho_\gamma} \right)^{1/\rho_\gamma} \tag{3.4}$$

$$\gamma = 1, \cdots, \Gamma$$

Stage Gamma

$$d_\delta = \left(\sum_{\gamma \in d\delta} C_\gamma c_\gamma^{\rho_\delta} \right)^{1/\rho_\delta} \tag{3.5}$$

$$\delta = 1, \cdots, \Delta$$

The functional relationship of the first group is given by (3.3), which indicates what product mixes can be obtained from a given bundle of resources; therefore b_β can be thought of as a measure of such a bundle. There are B aggregate products b_β. At the second stage they are aggregated into Γ groups, with c_γ representing a bundle of resources necessary to produce possible combinations given by (3.4). Again, it can be viewed as a measure of aggregate production of the c_γ group. If d is the last function, then its value is a measure of aggregate output. It is possible to follow the same procedure on the input side and get a measure of aggregate input, but this is not done here.

Finally, if each group in stage α consists of one variable only, we obtain the function derived by Mukerji [4]. In this case, a two-stage function reduces to a one-stage function with unequal *DES*'s.[1]

[1] It is well known that for pairs of variables belonging to the same group the contours are strictly concave to the axis when the ρ that applies to the group is greater than one. Thus, that part of the function which represents transformation curves cannot contain values of ρ smaller than one and in particular it does not admit $\rho=0$. When $\rho=0$, the function becomes of Cobb-Douglas type. Thus, aggregates of the form studied by Uzawa [11], where ρ of stage β is zero, cannot be adopted for product aggregation. Nor for that matter can the "block additive linear homogeneous" function studies by McFadden [2] be adopted for product aggregation.

4. Estimation—The Ostrich Approach

In general, the ACMS function is estimate by utilization of the first order conditions. Th advantage of such an approach increases whe more than one stage is contemplated.

The marginal rate of transformation (product α for product α^* within the β "cell" c aggregate is[2]

$$\frac{F_{\alpha^*}^{\beta}}{F_\alpha^{\beta}} = \frac{A_{\alpha^*}}{A_\alpha} \left(\frac{a_\alpha}{a_{\alpha^*}} \right)^{1/\sigma_\beta} \qquad \alpha, \alpha^* \in \beta \tag{4.1}$$

where

$$F_\alpha^{\beta} = \frac{\partial b_\beta}{\alpha a_\alpha} \quad \text{and} \quad \frac{1}{\sigma_\beta} = 1 - \rho_\beta < 0$$

Imposing competitive conditions (equatin marginal rates of transformations to the corr sponding price ratios), rearranging terms, an adding an error term u we get

$$\frac{a_{\alpha^*}}{a_\alpha} = \left(\frac{A_{\alpha^*}}{A_\alpha} \right)^{\sigma_\beta} \left(\frac{P_\alpha}{P_{\alpha^*}} \right)^{\sigma_\beta} e^{u}; \tag{4.2}$$

$$u \sim N(0, \sigma_u^{2}$$

Under these assumptions, σ_β and the coeff cients A_α (up to a constant) can be estimatec Furthermore, technical change can also b added by making A_α to depend on time. simple but still quite general assumption is

$$A_\alpha(t) = A_\alpha(0)e^{\lambda_\alpha t} \quad \lambda_\alpha \leq 0 \tag{4.3}$$

Equation (4.3) states that the production of given output a_α requires less and less resourc as a result of technical change. Alternativel we could write

$$a_\alpha(t) = a_\alpha(0)e^{\theta t} \quad \theta \geq 0. \tag{4.3*}$$

[2] Here and in subsequent discussion it will be convenie to note the following: Let a given aggregate be

$$Y = \left(\sum_i A_i X_i^{\rho} \right)^{1/\rho}$$

Then

$$\frac{\partial Y}{\partial X_i} = A_i \left(\frac{Y}{X_i} \right)^{1-\rho}$$

Consequently

$$\frac{\partial Y/\partial X_i}{\partial Y/\partial X_j} = \frac{A_i}{A_j} \left(\frac{X_j}{X_i} \right)^{1/\sigma}$$

$$\sigma = \frac{1}{1-\rho}$$

The first-order condition requires $\partial Y/\partial X_i = P_i/P_y$

Equation (4.3)* states that when total amount of resources and their allocation remain unchanged, the output of the a_α product will grow geometrically at a rate θ.

Combining (4.2) and (4.3), we have

$$\frac{a_{\alpha*}(t)}{a_\alpha(t)} = e^{(\lambda_{\alpha*}-\lambda_\alpha)\sigma_\beta t} \cdot \left[\frac{A_{\alpha*}(0)}{A_\alpha(0)}\right]^{\sigma_\beta}\left[\frac{P_{\alpha*}(t)}{P_\alpha(t)}\right]^{-\sigma_\beta} \tag{4.4}$$

Once all coefficients (A_α's, λ_α's and ρ_β's) in the first stage are estimated the b_β aggregates can be estimated from equation (3.3). It should be noted that in each cell of the first stage we normalize the A coefficients so that one of the coefficients is factored out. Similarly, one of the B coefficients is factored out in each of the γ cells, etc.

To continue with the estimation we now need a price P of the aggregate product b. Applying Uzawa's duality results [11] we obtain[3]

$$P_\beta(t) = \left[\sum_{\alpha\in b_\beta} A(t)_\alpha^{\sigma_\beta} P(t)_\alpha^{1-\sigma_\beta}\right]^{1/(1-\sigma_\beta)} \tag{4.5}$$

We now continue in a straightforward fashion. Analogously to (4.4) we now have

$$\frac{b_{\beta*}}{b_\beta} = e^{(\lambda_{\beta*}-\lambda_\beta)\sigma_\gamma t}\left(\frac{B_{\beta*}}{B_\beta}\right)^{\sigma_\gamma}\left(\frac{P_{\beta*}}{P_\beta}\right)^{-\sigma_\gamma} \tag{4.6}$$

The function was used in an attempt to construct the product component of multiproduct function for Israel agriculture. The period of analysis is 1954–68. It should be mentioned that estimation of first-order conditions requires an explicit recognition of variables that play a role in producers' response to prices. We have used a simple partial adjustment model leading to distributed lag analysis. The computed regression equations were of the form:

$$q_t = b_0 + b_1 p_{t-j} + b_2 t + b_3 q_{t-1} + v_t \qquad j = 1, 2 \tag{4.7}$$

where

$q_t = ln\ a_{\alpha*}/a_\alpha$ for stage Alpha,
$ln\ b_{\beta*}/b_\beta$ for stage Beta, etc.
$p = ln\ P_{\alpha*}/P_\alpha$ for stage Alpha,
$= ln\ P_{\beta*}/P_\beta$ for stage Beta, etc.
v_t = disturbance.

The estimates of the pertinent parameters are given by

$$\begin{aligned} \hat{\theta} &= -b_1/1 - b_3 \\ \hat{\lambda} &= (\lambda_{\alpha*} \hat{-} \lambda_\alpha) = -b_2/b_1 \\ (A_{\alpha*} \hat{/} A_\alpha) &= e^{-b_0/b_1} \end{aligned} \tag{4.8}$$

The grouping was done according to natural considerations relevant to the industry. This, of course, does not give a unique criterion, but at the same time the choice is limited. We thus start with grouping vegetables and potatoes; poultry, meat, and eggs; etc. The grouping can be seen in Figure 3, which also summarizes the estimates of σ's for the various groups. The detailed estimates are given in Table 1. In the choice of a particular estimate among the various available estimates, the following consideration was made: On a priori knowledge, we expected to have substitution at least at the lower stages. Thus we first chose estimates that had the right sign and then among those selected

[3] The aggregate price is the value of the revenue function for the unit transformation curve. The revenue function is defined as follows [3]:

$$R(v, p_a) = \max_a \left\{ \sum_{\alpha\in\beta} p_\alpha a_\alpha \mid H(a, v) = 0 \right\}$$

where v is the vector of resources, P_a the vector of product prices $\{P_\alpha\}$, a the vector of outputs $\{a_\alpha\}$, and $H(a, v)$ is the production function that describes all the possible outputs a attainable from the vector of resources v. Thus the revenue function is a function of the product prices and the available resources.

To obtain the aggregate price of stage Alpha in our case, we write

$$p_\beta(p_a) = \max_a \left\{ \sum_{\alpha\in\beta} p_\alpha a_\alpha \mid b_\beta(a_\alpha) = 1 \right\}$$

P_β is obviously a function of the prices P_a alone. For vector price P_a, we select the output composition a on the unit transformation curve ($b_\beta = 1$) which maximizes revenue.

To illustrate, we outline the derivation of P_β for

(i) $$b = (A_1 a_1^\rho + A_2 a_2^\rho)^{1/\rho}$$

From the first-order conditions we obtain [see (4.2) above]

(ii) $$a_1 = (A_1 p_2 / A_2 p_1)^\sigma a_2$$

Substituting (ii) in (i) and setting $b = 1$, we get

(iii) $$a_2 = (A_1^\sigma p_1^{-\rho\sigma}(p_2/A_2)^{\rho\sigma} + A_2)^{-1/\rho}$$

Substituting (iii) in (ii), we can have both a_1 and a_2 as functions of prices alone. Finally those functions are replaced in $\sum_{\alpha\in\beta} P_\alpha a_\alpha$ to get

$$p_\beta = p_1 a_1(p_1, p_2) + p_2 a_2(p_1, p_2)$$

which yields (4.5).

It should be noted that in our case b is a homogeneous function of the first degree in the a's. When b is homogeneous of degree other than one, a scale factor will enter the expression [7, p. 173].

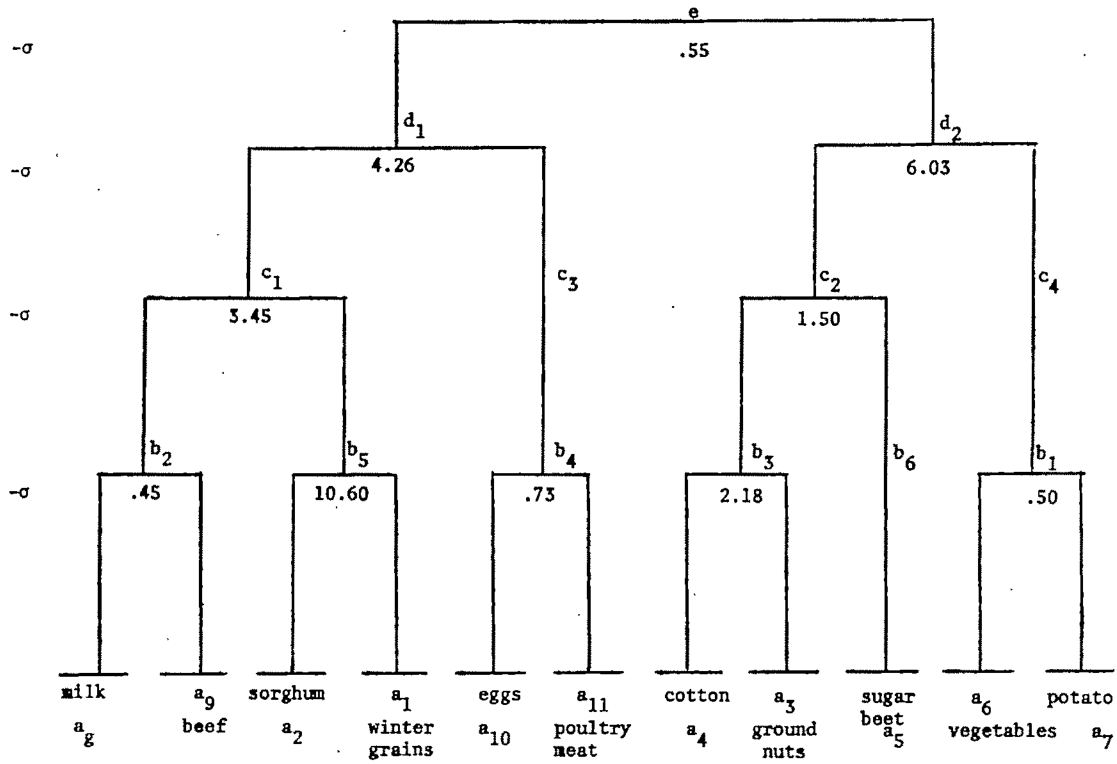

Figure 3. Product substitution in Israel agriculture

the ones with a smaller sampling error. The inclusion of a lagged dependent variable had a significant effect in only three of the regressions.

There is a temptation to say that the results do not show high substitution within some cells, except that it is not so clear what is high substitution. Ignoring the extreme case of perfect substitution, we actually do not have a good criterion, other than empirical, for judgment. At the same time, we do not yet have empirical evidence on that question, and we shall have to wait for empirical results in order to compare degree of substitution. Generally speaking, the relative stability, aside from trends, of composition of production serves perhaps as a rough indication of imperfect substitution. This is stated with some reservation in view of the variety of possibilities that contribute to stability in product composition which may offset high substitution.

How can one judge the reasonableness of the results? If we look at the goodness of fit, we see that R^2 varies among the various equations from .401 to .920. Yet there is no measure of fit of the final aggregate, since such an aggregate by its very nature is not an observable quantity. However, a partial check is available b looking at the revenue. As we recall, (4.5) pr vides an aggregate price of the aggregate give by (3.3). Consequently, their product gives computed revenue which can be compared wit the actual revenue. Such a comparison is give for the final stage of aggregation (stage *e*) i Table 2.[4] From it we see that there is a ver close agreement between the two sets of figure Similar agreement is obtained for the aggregat at the lower stages.

It is interesting to note that the compute revenue is larger than the actual one in a years. The computed revenue is obtained b selecting the optimal outputs under the give prices and under the assumption that the tech nology is given by the estimated productio function. Deviations from the optimal outpu reduce revenue. On the other hand, if the tech nology is given by another production functio it is possible that actual revenue will be large The results indicate that the net effect of devia tions from the optimal outputs and of errors i

[4] Actual revenue is simply the value product in curre prices; that is, it is the sum of the value of outputs of the components of the aggregate.

Table 1. Regressions for the various stages[a]

Pairs[b]	Price lag[c]	R^2	b_0	b_1	b_2	b_3[d]
$b_2: a_8, a_9$	2	.787	7.268 (10.51)	.449 (2.45)	−.047 (2.83)	
$b_3: a_2, a_1$	1	.681	− .025 (.08)	1.950 (2.20)		.816 (4.73)
$b_4: a_{10}, a_{11}$	2	.877	6.065 (3.82)	.732 (1.56)	−.097 (4.53)	
$b_5: a_3, a_4$	2	.957	3.342 (9.76)	2.183 (5.29)	−.378 (14.47)	
$b_1: a_6, a_7$	2	.401	.969 (21.04)	.500 (2.95)		
$c_1: b_5, b_2$	2	.561	−9.630 (4.69)	3.45 (3.42)	.071 (1.96)	
$c_2: {}_5a, b_3$	2	.836	3.250 (2.63)	1.497 (2.79)	.257 (6.46)	
$d_1: c_1, b_4$	2	.423	1.651 (1.95)	1.222 (1.37)	—	.713 (2.92)
$d_2: c_2, b_3$	1	.773	− .717 (2.66)	1.381 (2.37)	−.070 (2.32)	.771 (4.85)
$e: d_2, d_1$	1	.920	−3.483 (8.14)	.547 (2.12)	−.088 (6.14)	

[a] The regression coefficients b_0, b_1, b_2, b_3 are those of equation (4.7). Numbers in parenthesis are ratios of the coefficients to their standard errors.
[b] See Figure 1 for definitions of a's. The first number of the pair constitutes the numerator of (4.4)-like equations.
[c] 1 and 2 indicate price lags of one and two years respectively.
[d] Blank spaces indicate that b_3 was not significantly different from zero. The remaining coefficients were recalculated after dropping q_{t-1}.

Table 2. A comparison of actual and computed revenue—final stage

Year	Actual	Computed	Computed/actual
	million IL—current prices		percent
1954	157	165	105
1955	194	196	101
1956	251	257	102
1957	304	311	102
1958	362	369	102
1959	397	401	101
1960	415	422	102
1961	492	495	101
1962	532	541	102
1963	602	614	102
1964	692	712	103
1965	745	752	101
1966	763	769	101
1967	876	882	101
1968	924	941	102

the specified and estimated production function is small and all in one direction.

5. Estimation—A Broader View

Better data, more observations, and more refined expectation models might serve well in improving the estimates as presented in the foregoing section. However, when this is all done, one still has to face all the restrictions imposed by the model. The simplicity of the estimation procedure indicated above is merely a result of the fact that the marginal rate of transformation of a pair of products within a given cell is independent of other products within or outside the particular cell. This is a strong form of separability. Any convenience has a price and this is also true for separability. The particular restrictions we refer to are those of marginal rates of transformation between pairs from different cells. Using the chain rule of differentiation, a general expression for the marginal rate of transformation between α and α^* for a two-stage function, $F(.)$, is given by

$$\frac{F_\alpha}{F_{\alpha^*}} = \frac{F_{\beta}{}^{\gamma} F_{\alpha}{}^{\beta}}{F_{\beta^*}{}^{\gamma} F_{\alpha^*}{}^{\beta^*}} \tag{5.1}$$

where as before $F_\alpha = \partial F/\partial a_\alpha$, etc.

Substitute in (5.1) for the partial derivatives:[5]

$$\frac{F_\alpha}{F_{\alpha^*}} = \frac{A_\alpha B_\beta}{A_{\alpha^*} B_{\beta^*}} \left(\frac{b_\beta}{a_\alpha}\right)^{1/\sigma\beta} \left(\frac{b_{\beta^*}}{a_{\alpha^*}}\right)^{-1/\sigma\beta^*} \left(\frac{b_{\beta^*}}{b_\beta}\right)^{1/\sigma\gamma} \tag{5.2}$$

Using the equality of marginal rates of transformation with the appropriate prices and simplifying,[6]

$$\frac{a_\alpha{}^*}{a_\alpha} = \frac{A_{\alpha^*}{}^{\sigma\beta^*} B_{\beta^*}{}^{\sigma\gamma}}{A_\alpha{}^{\sigma\beta} B_\beta{}^{\sigma\gamma}} \left(\frac{P_\alpha}{P_\beta{}^{\kappa}}\right)^{\sigma\beta} \cdot \left(\frac{P_{\alpha^*}}{P_{\beta^*}}\right)^{-\sigma\beta^*} \left(\frac{P_\beta}{P_{\beta^*}}\right)^{\sigma\gamma} \tag{5.3}$$

[5] To obtain (5.2), use successively the expression obtained in footnote 2. For instance,

$$F_{\beta}{}^{\gamma} = \frac{\partial c_\gamma}{\partial b_\beta} = B_\beta \left(\frac{c_\gamma}{b\beta}\right)^{1/\sigma\gamma}$$

[6] To obtain (5.3), first, note that $F_\alpha/F_\alpha{}^* = P_\alpha/P_\alpha{}^*$. Second, write $P_i/P_y = A_i(Y/X_i)^{1/\sigma}$ and apply it successively to (5.2).

So we obtain

$$\frac{b_\beta{}^*}{b_\beta} = \left(\frac{B_\beta{}^*}{B_\beta}\,\frac{p_\beta}{p_\beta{}^*}\right)^{\sigma\gamma}$$

$$\frac{b_\beta}{a_\alpha} = \left(\frac{1}{A_\alpha}\,\frac{p_\alpha}{p_\beta}\right)^{\sigma\beta} \text{ etc.}$$

Rewrite (5.3)

$$\frac{a_\alpha{}^*}{a_\alpha} = \frac{p_\alpha{}^*}{p_\alpha}\,\frac{A_\alpha B_\beta}{A_\alpha{}^* B_\beta{}^*}\left(\frac{b_\beta}{a_\alpha}\right)^{1+1/\sigma\beta}\left(\frac{a_\alpha{}^*}{b_\beta{}^*}\right)^{1+1/\sigma\beta^*}\left(\frac{b_\beta{}^*}{b_\beta}\right)^{1+1/\sigma\gamma}$$

$$= \frac{A_\alpha B_\beta}{A_\alpha{}^* B_\beta{}^*}\left(\frac{p_\alpha/A_\alpha}{p_\beta}\right)^{1+\sigma_\beta}\left(\frac{p_\beta{}^*}{p_\alpha{}^*/A_\alpha{}^*}\right)^{1+\sigma\beta^*}\left(\frac{p_\beta/B_\beta}{p_\beta{}^*/B_\beta{}^*}\right)^{1+\sigma\gamma}$$

which upon simplification yields (5.3).

Equation (5.3) gives another relation for estimating the parameters in question. That is, σ_β and σ_{β^*} were previously estimated from regressions of pairs within their respective cells. Similarly was σ_γ estimated at a higher stage. Now we use pairs, each member of which comes from a different cell. Thus, there are several such estimates. To apply this method, estimates were obtained for pairs which are second-order nested. For instance, referring to Figure 3, we take the pairs at the Alpha stage which are nested within the Gamma stage (a_1 and a_8, etc). Similarly, we take the pairs at Beta stage which are nested within the Delta stage, etc. The estimates were obtained by computing regressions of the logarithms of (5.3)-like equations. The price aggregates, such as P_β, that appear in the equations were those used in section 4. But those are the pertinent aggregates only if the original grouping is the correct one. Thus, the current regressions should be viewed as conditional on the assumption of correct grouping.

The purpose of this discussion is to emphasize the importance of checking the consistency of a particular grouping scheme. To save space we do not report the actual results, which are summarized as follows: In *some* cases there is a wide spread between the alternative estimates. However, approximate statistical tests indicate that to a large extent the spread is due to sampling error. More conclusive results require a larger sample than the one used here.

6. Some Further Comments

One specific form of the function dealt with is that suggested by Mukerji [4], which can be written as

$$b = \left(\sum_\alpha A_\alpha a_\alpha^{\rho_\alpha} \right)^{1/\rho} \tag{6.1}$$

This function can be viewed as a two-stage function with one product per cell at the Alpha stage.

Since there is no good empirical procedure to group the products, it is impossible to determine empirically whether the cells consist of only one product. If it were known that (6.1) is the right function, then by equating the marginal rates of transformation with the pertinent price relatives the following relations can be obtained for empirical analysis:

$$\frac{a_{\alpha^*}}{a_\alpha} = \theta \left(\frac{p_{\alpha^*}}{P_\alpha} \right)^{\sigma_{\alpha^*}} a_\alpha^{\tau_\alpha} \tag{6.2}$$

where θ is a constant,

$$\sigma_{\alpha^*} = \frac{1}{1 - \rho_{\alpha^*}} \quad \text{and} \quad \tau_\alpha = \frac{\rho_\alpha - \rho_{\alpha^*}}{\rho_{\alpha^*}}$$

Comparing (6.2) with (4.2), the test is simple. If τ_α is significantly different from zero, then (6.1) is the relevant expression for the pair under consideration. Such a test can be repeated for the remaining pairs.

All this is fine when it is known that a_α and a_{α^*} come from the same cell in the multistage production function. If this is not the case, (6.2) should be compared, not with (3.2), but rather with expressions like (5.3). The comparison then becomes more complicated, but in any case a result of $\tau \neq 0$ in (6.2) cannot be interpreted to mean that the pair comes from (6.1). In fact, what we have here is a situation with a left-out variable, and τ can take on any value.

The discussion in section 5 presented a final check on any grouping scheme. The question is whether there are any indicators that can be used in the process of grouping. The situation is far from satisfactory. However, a few observations can be made. It is noted that, by definition, for all pairs in the b_β cell ρ_β is the same. However, the reverse is not necessarily true. To see this, consider the following c aggregate in which we impose $\rho_{b1} = \rho_{b2} = \rho_\beta$:

$$\begin{aligned} c_\gamma^{\rho_\gamma} &= B_1[A_1 a_1^{\rho_\beta} + A_2 a_2^{\rho_\beta}]^{\rho_\gamma/\rho_\beta} \\ &\quad + B_2[A_3 a_3^{\rho_\beta} + A_4 a_4^{\rho_\beta}]^{\rho_\gamma/\rho_\beta} \\ &= B_1 b_1^{\rho_\gamma} + B_2 b_2^{\rho_\gamma} \end{aligned} \tag{6.3}$$

We cannot combine the two cells into one unless we also have $\rho_\gamma = \rho_\beta$ which yields

$$c_\gamma^{\rho_\gamma} = B_1 A_1 a_1^{\rho_\gamma} + \cdots + B_2 A_4 a_4^{\rho_\gamma} \tag{6.4}$$

Does it mean that under (6.4) the number of stages has necessarily been reduced? The answer is no. There can be another cell in c_γ, say b_3 for which $\rho_{b_3} \neq \rho_\gamma$. Alternatively, there can be another c aggregate, say c_γ^* which cannot be expressed as (6.3). The conclusion is that equality of σ's in a pair-wise estimation is not necessarily a good criterion for grouping. On the other hand, if we know what products belong to a cell, say the b_β cell, we can impose on (4.4) equality of σ_β.

It appears that such statistical tests are of little relevance in the process of grouping. The only pertinent null hypothesis is that of sign of σ_β. Pairs that give the wrong sign cannot, on a priori ground, belong to the same group. However, a value of $\sigma_\beta = 0$, which generally constitutes the null hypothesis, does not serve the

purpose here. Such a value implies fixed proportions. We can certainly start by aggregating all components that are produced in fixed proportions. Another extreme case that is equally good to start with in aggregating the products is that of perfect substitution. Perhaps here we should feel a little uncomfortable. We know that in a perfect market only a coincidence will lead to diversification under perfect substitution. However, this is not a major difficulty. Various assumptions can remedy it. One that may serve well is the introduction of uncertainty.

In view of all the difficulties, it is likely that compromises will have to be made in the utilization of such a function. Grouping will be done according to similarity in technology. The test will have to be somewhat less restrictive than the one used here; it will be a test of usefulness. The question to be answered is whether a generalization of the function of the sort discussed here provides useful results not obtainable from a simpler form. Consciously or otherwise, this is after all the dominating test in empirical analyses.

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Research Notes

Withholding by Grade

FREDERICK V. WAUGH

SUPPOSE AN agricultural industry plans to withhold from market a part of a crop. Would the industry increase its income more by withholding (a) only the lower grades, (b) more than one grade, or (c) only the upper grades? Some marketing experts apparently believe that the answer is obvious—that the industry should always withhold only the lower grades. Like many other dogmas, this one "ain't necessarily so."

Only economic analysis can determine what kind of withholding is the most profitable in any given case. Such an analysis can use the methods of Robinson [2], Simkin [3], and Hoos and Seltzer [1].

Illustrative Example

We consider here only the case of two grades. Let q_1 and q_2 be the quantities of grades 1 and 2 that are marketed; and let p_1 and p_2 be the corresponding net prices to producers.

To illustrate the problem, I shall assume that

$$(1)\qquad \begin{aligned} p_1 &= 100 - 3q_1 - q_2, \\ p_2 &= 50 - q_1 - 2q_2. \end{aligned}$$

I shall assume that these equations hold when $10 \leqq q_1 \leqq 25$ and $0 \leqq q_2 \leqq 10$. Within these limits both prices are positive and $p_1 > p_2$. In these respects, at least, the equations seem realistic.

The net returns from both grades together are

$$(2)\qquad \begin{aligned} R = q_1p_1 + q_2p_2 = 100q_1 - 3q_1^2 - 2q_1q_2 \\ + 50q_2 - 2q_2^2. \end{aligned}$$

From (2) one can compute net returns from various combinations of grades, as in Table 1.

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Table 1. Returns from various combinations (q_1, q_2)

$q_2 =$	$q_1 =$ 10	15	20	25
0	700	825	800	625
5	800	875	800	575
10	800	825	700	425

The greatest possible net returns are from a combination of 15 units of grade 1 and 5 units of grade 2, resulting in net returns of 875.

The table shows many situations in which the withholding of grade 1 would be more profitable than the withholding of grade 2. Suppose, for example, that the industry has available 25 units of grade 1 and 10 units of grade 2. If all units of both grades are marketed, net returns are 425. They could be raised to 625 by withholding all 10 units of grade 2; but they could be raised to 825 by withholding 10 units of grade 1 (marketing 15 units of grade 1 and 10 units of grade 2). Or they could be raised to 800 by withholding 5 units of each grade.

What happens if the industry must meet some quota, $Q = q_1 + q_2$? Then net returns from each grade must be equal, say, to λ. The constrained maximum is found in our example by solving the simultaneous equations:

$$(3)\qquad \begin{aligned} 100 - 6q_1 - 2q_2 &= \lambda \\ 50 - 2q_1 - 4q_2 &= \lambda \\ q_1 + q_2 &= 25. \end{aligned}$$

The solution is $q_1 = 16\ 2/3$, $q_2 = 8\ 1/3$, $\lambda = -16\ 2/3$. That is, the most profitable division of the quota is into 16 2/3 units of grade 1 and 8 1/3 units of grade 2. If the available supplies are 25 units of grade 1 and 10 units of grade 2, the most profitable program is to withhold 8 1/3 units of grade 1 and 1 2/3 units of grade 2.

Conclusion

The most profitable form of withholding in any particular case depends upon the pair of price equations and upon the available supply of each grade. No panacea, such as withholding of the lower grades alone, will be the most profitable in all cases. To the contrary, the industry might well find in many cases that it could gain more from withholding grade 1 or by withholding some of both grades.

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On Estimating Capital Gains in U. S. Agriculture*

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CAPITAL GAINS accruing in the farm sector have figured prominently in discussions of farm incomes and policy in recent years. Professional interest in estimating capital gains owes mainly to the need for comprehensive measures of income and changes in farmers' welfare, and parity between farm and nonfarm sectors. It is recognized that inflationary pressures have contributed to increase in market value of farm assets; but even when changes in general price level are allowed for, capital gains loom large. Several estimates of farm capital gains and losses have been made, but they differ in scope, methodology, and concepts. Grove [5] and Hathaway [6] computed nominal capital gains, whereas Boyne [4] and Hoover [7] corrected their estimates for changes in purchasing power. Furthermore, Grove did not include financial assets and liabilities, nor did he calculate gains on individual classes of assets. Boyne and Hoover estimated gains on all farm assets and liabilities.[1] This note presents estimates of nominal and real gains accruing on some farm assets during the period 1947–1968; its main purpose is to show how different definitions and methods affect the final estimates of gains and losses in the farming sector. For brevity, the term "gains" includes both gains and losses.

Value of assets increases because of net investment and price appreciation. Estimating capital gains essentially involves isolation of these components:

Let

V_t = the market value of an asset at the end of year t,

A_t = the amount of net investment in the asset during t,

P_t = the average price of the asset at the end of year t, and

G_t = the amount of capital gains accruing in year t.

Capital gains can be estimated by subtracting net investment from changes in market value (equation 1), by using a price index (equation 2), or from a value series in constant dollars (equation 3). In our notation, these methods can be stated as follows:

$$(1) \qquad G_t = V_t - V_{t-1} - A_t$$

$$(2) \qquad G_t = V_{t-1}\left(\frac{P_t}{P_{t-1}} - 1\right)$$

$$(3) \qquad G_t = V_t - V_{t-1} - Q_t$$

where Q_t is the quantity component of a change in value derived from a value series in constant dollars.[2]

The above equations can be shown to be equivalent. The three approaches thus would lead to the same estimates of accrued capital gains; should the results differ, the discrepancy would have to be attributed to the data used.[3]

Changes in general price level can be easily incorporated into any of these methods to estimate real capital gains G_t^*. All variables in equation (1) can be stated in terms of prices of some base year to estimate G_t^*. For example, if year t is chosen as the base year,

* I would like to thank Mardy Myers, Bruce Johnson, and other USDA officials for helpful discussions. The editor's suggestions have also improved the paper.

[1] This should not be interpreted as a criticism of Grove's study. Most financial assets held in the farm sector have a fixed face value (e.g., cash balances, bonds, loan value of life insurance, etc.), which rules out nominal gains. Grove did not undertake estimates of real capital gains.

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[2] Following Boyne [4], the "quantity component" of a change in value can be estimated in two ways from a value series in constant dollars:

$$Q_1 = V_i\left(\frac{P_bQ_{i+1}}{P_bQ_i} - 1\right)$$

$$Q_2 = V_{i+1}\left(1 - \frac{P_bQ_i}{P_bQ_{i+1}}\right)$$

where P_bQ_i is the ith term in the constant dollar value series and V_i is the corresponding term in the current dollar value series. A simple average of Q_1 and Q_2, valued at the average price during the period, can then be used as the quantity component.

[3] The methods discussed here are designed to estimate capital gains on individual classes of assets. If gains have to be estimated on all assets and liabilities together, capital gains can be computed by subtracting total net investment from change in farmers' net worth. This is Goldsmith's net worth approach. However, this also yields the same results as equations (1), (2), and (3). For details of Goldsmith's approach and a proof of the equivalence of the various approaches, see Bhatia [1].

$$(4) \quad \begin{aligned} G_t^* &= V_t - V_{t-1}\left(\frac{I_t}{I_{t-1}}\right) - A_t \\ &= G_t - V_{t-1}\left(\frac{I_t}{I_{t-1}} - 1\right) \end{aligned}$$

where I is an index of the general price level. Another way of estimating real capital gains is by subtracting the rate of change in the general price level from the rate at which nominal capital gains accrue. Real and nominal capital gains then would be defined analogously to real and nominal rates of interest.[4]

We have value estimates in current and constant dollars and a price index for farm real estate; so capital gains can be estimated by all the approaches described above. But similar data are not available for other asset types. Therefore, in what follows, alternative estimates of nominal capital gains are presented for real estate only; for other assets, nominal gains are estimated by equation (1); real capital gains are computed for all the assets from equation (4).

Estimates of Capital Gains

Farm real estate

USDA figures on market value of farm real estate that appear in *The Balance Sheet of the Farming Sector* (formerly the *Balance Sheet of Agriculture*) are derived by multiplying the estimated acreage of farmland as of January 1 each year by the estimated value per acre (including structures) as of March 1 of the same year. This series is then published as value relating to January 1 of each year.[5] Both the price per acre and the number of acres are based on interpolations from benchmarks derived from the Census of Agriculture.

Year-end market values of farm real estate are needed to estimate accrued capital gains. Value of farmland is derived by multiplying the acreage estimated for the USDA series by the year-end price, which is calculated by linear interpolation between the average price in March of various years. The adjusted series on market value of farm real estate exceeds the official figures by 4–5 percent in most years and is used in all the computations reported in this article.[6]

Alternative estimates of capital gains accruing on farm real estate are presented in Table 1.[7] The three estimates of nominal capital gains agree in sign every year but the magnitudes differ. For the years 1947–1968, capital gains computed from equations (1) and (2) (referred to as G_1 and G_2, respectively) differ by less than 5 percent; however, they exceed the results derived from equation (3) (referred to as G_3) by about 15 percent. The amounts involved are

Table 1. Estimates of capital gains on farm real estate, United States[a]

Year	Nominal gains: Equation (1)	Nominal gains: Equation (2)	Nominal gains: Equation (3)	Real gains
	billion dollars			
1947	9.26	9.89	9.32	−1.19
1948	3.11	3.91	3.23	−1.21
1949	−0.81	−0.12	−0.61	1.78
1950	6.59	7.31	6.77	5.70
1951	8.34	9.05	8.33	0.56
1952	2.43	3.13	2.13	1.45
1953	−1.41	−0.81	−1.57	−0.39
1954	2.15	2.55	1.92	2.15
1955	4.55	4.83	3.68	3.52
1956	7.29	7.64	6.45	6.22
1957	7.33	7.64	6.31	3.94
1958	7.85	8.14	7.05	6.68
1959	5.77	6.05	4.76	4.54
1960	3.61	3.81	2.99	2.34
1961	4.92	5.00	4.16	4.92
1962	6.34	6.33	5.46	5.00
1963	8.75	8.66	7.72	7.37
1964	9.29	9.10	8.13	7.84
1965	11.07	10.89	9.44	8.04
1966	11.78	11.33	10.20	7.04
1967	12.40	11.99	10 73	7.50
1968	10.87	10.36	9.15	4.12
Total	141.48	146.68	125.75	87.89

[a] Alaska and Hawaii not included.

[4] This method is applicable to physical assets only. On financial assets that have a fixed nominal dollar value, real capital gains depend on changes in the general price level only. Accordingly,

$$G_t^* = -V^f_{t-1}\left(\frac{I_t}{I_{t-1}} - 1\right)$$

where superscript f denotes a financial asset.

[5] This point emerged during discussions with Bruce Johnson of the USDA. USDA has greater confidence in its March than in its November estimate.

[6] It is recognized that the adjustment procedure is inadequate, but the small difference should not detract from the need for correcting this confusion about timing in the official series. Even a 4–5 percent adjustment could alter estimates of capital gains significantly, because generally gains have been a small fraction of the value of farmland.

[7] They all use the data series compiled by the USDA. The value series is adjusted to derive year-end estimates. Data on net investment are from [10], but are adjusted to include the value of net changes in the acreage of farmland. The index of average value per acre is from [8, p. 61, Table 38].

small, but the differences in annual estimates are larger. For example, in 1948, G_2 is greater than G_1 and G_3 by about 25 percent; in 1960, G_2 exceeds G_1 by 7 percent and G_3 by about 20 percent.

As mentioned above, the differences between the various estimates of capital gains have to be attributed to the underlying data series. Equations (1) and (2) use the same series of market value (V_t), but (1) uses the official estimates of net investment, and (2) uses the index of average value per acre of farm real estate. Until 1961, G_2 is greater than G_1, although G_1 exceeds G_2 during the period 1962–1968. These differences could be explained if the following hypotheses about the data series hold:

(1) The USDA series overstates the true net investment in farm real estate but has had a downward bias since 1961.

(2) The index of average price per acre is biased upwards; since 1961, however, the underestimation in the investment series has exceeded the overestimation of the average value per acre.

As G_1 and G_2 exceed G_3, it is likely that the constant dollar value series overstates the quantity component of change in value. A detailed discussion of the USDA series is not presented here; these hypotheses, however, are consistent with biases suspected in the USDA estimates.[8]

Table 2. Estimates of capital gains on livestock, machinery and motor vehicles, and crop inventories, United States[a]

Year	Livestock		Crop inventories		Machinery and motor vehicles	
	Nominal (1)	Real (2)	Nominal (3)	Real (4)	Nominal (5)	Real (6)
	billion dollars					
1947	2.0	0.0	3.1	2.1	1.0	0.1
1948	1.2	0.4	−2.2	−2.7	1.1	0.7
1949	−1.7	−1.1	0.1	0.4	0.5	0.8
1950	3.6	3.5	0.1	0.0	0.6	0.5
1951	1.4	−0.1	0.7	0.0	1.5	1.2
1952	−5.3	−5.5	−0.1	−0.2	0.1	−0.1
1953	−3.0	−2.7	0.7	0.8	0.5	0.7
1954	−0.8	−0.8	0.1	0.1	0.1	0.1
1955	−0.6	−0.7	−1.5	−1.6	0.5	0.3
1956	0.7	0.6	0.1	0.0	1.3	1.1
1957	3.1	2.8	−1.5	−1.8	0.2	−0.4
1958	3.2	3.1	2.0	1.9	1.3	1.1
1959	−2.9	−3.1	−1.3	−1.4	0.3	0.1
1960	0.3	0.2	0.0	−0.1	0.0	−0.2
1961	0.4	0.4	0.8	0.8	0.7	0.7
1962	0.3	0.2	0.5	0.4	0.4	0.2
1963	−1.9	−2.1	0.2	0.1	0.9	0.7
1964	−1.2	−1.3	0.2	0.1	0.9	0.7
1965	3.2	2.9	−0.7	−0.9	0.8	0.3
1966	1.6	1.1	0.6	0.3	0.8	0.0
1967	0.0	−0.5	0.9	0.6	1.1	0.3
1968	1.5	0.8	1.1	0.8	1.0	−0.1
Total	5.1	−1.9	3.9	−0.3	15.6	8.8

[a] Alaska and Hawaii not included.

Other assets

Capital gains on livestock, crop inventories, and machinery and motor vehicles computed from equation (1) are presented in Table 2. Relatively small gains have accrued in these asset classes. For 1947–1968 their nominal gains were about 20 percent of the lowest of those on farm real estate. However, these figures could be misleading. Most capital gains that accrue in livestock and crops during a year are realized by sale; gains estimated here relate only to inventories at the end of the year. In this respect there is a basic difference between these assets and real estate assets.

Real and nominal gains

Tables 1 and 2 also present capital gains after correcting them for changes in purchasing power. The USDA index of cost of family living is used to represent changes in the general price level. For 1947–1968, real capital gains on farm real estate amounted to $87.89 billion. In 1949 a fall in the cost of living index converted a nominal loss into a real gain, but in 1947 and 1948 inflation in the general price level wiped out nominal gains on farm real estate. This happened more frequently with livestock and crop inventories, for which there was a nominal gain of $9 billion but a real loss of $3.6 billion during 1947–1968. For machinery and motor vehicles the real gains were $8.8 billion; nominal gains, $15.6 billion. For all assets nominal gains were $166.1 billion; real gains, $94.5 billion. For a complete analysis, financial assets and

[8] The official estimates of net investment do not include most public investment in flood control, irrigation, etc., which has been capitalized into the value of farm real estate. Some items of disinvestment are also omitted, but there is a strong possibility that the series has been biased downward in recent years. For a critical evaluation of the methodology and data sources used in the official series, see Bhatia [3].

It is difficult to distinguish between price and quality changes, and the index of average value does not indicate "pure price appreciation" only. The value series also have limitations, for the current dollar estimates are based on subjective evaluation rather than actual market transactions and the price deflators used to compute the constant dollar series are not very satisfactory. (Cf. Bhatia [2, Ch. 6]). Part of the difficulty arises because most of these series have not been documented properly.

liabilities should also be taken into account, but doing so did not alter the aggregate estimates of real gains significantly. Total real gains increased by about $4.5 billion when gains on financial assets were included.[9]

A Critical Evaluation

How much confidence can be placed in the estimates derived here? The USDA series on market value of farm real estate has been adjusted. Possible errors in estimates of net investment and price changes have been pointed out; however, it has not been possible to adjust these series. For livestock, crop inventories, and other assets, we have accepted the available estimates. The validity of the results presented in Tables 1 and 2 depends crucially on quality of data. Alternative estimates could be made for real estate only, and for this reason alone one can have more trust in the estimates of capital gains on farm real estate.[10]

Because of the increase in the general price level, real gains were only about 56 percent of nominal gains. Capital gains have been quite large relative to the conventional measures of farm income (Table 3), amounting to more than 50 percent in some years. Similar estimates have been made by the author for the personal sector of the U. S. economy (including farms) also [1],[11] but in most years capital gains are not as large a fraction of personal income as in the farm sector. This result implies that if all capital gains are included in income, and incomes of the farm and nonfarm sectors are compared, the farm sector will fare much better than what similar comparisons based on conventional measures of income would indicate.

It is not correct to attribute all capital gains to farmers or farm operators, but it is difficult to get reliable information on assets owned by nonfarmers. Arbitrary adjustments have been made by other writers for assets owned by nonfarmers. Hoover assumed that farmers owned three-fourths of all farm real estate and other farm assets [7, p. 934, footnote to Table 1]. Boyne estimated that in most years farm operators owned about 70 percent of all farm real estate [4, p. 74, App. Table 3]. We do not make any new estimates of the fraction of gains actually accruing to farm operators, but the appropriate adjustment should be made if capital gains are used to compare *farmers' income* rather than *farm income*.

Table 3. Nominal capital gains and income for selected years

Year	Farm income (1)	Farm capital gains (2)	Farm gains as percent of farm income (3)	Accrued gains as percent of personal income (4)
	billions of current dollars			
1948	21.0	3.2	15.2	7.4
1950	16.9	10.9	64.5	21.8
1955	14.5	3.0	20.7	23.3
1960	15.9	3.9	24.5	1.7
1964	16.7	9.2	55.1	19.6
1968	20.2	14.5	71.8	n.a.

Source: Column 1: [10, p. 51, Table 8H]; column 2: sum of column 1, Table 1, and columns 1, 3, 5, Table 2; column 3: (column 2 ÷ column 1) × 100; column 4: computed from Tables 1 and 2 in Bhatia [1].

[9] Data on value of financial assets and liabilities were taken from [8]. Investment in cooperatives was excluded from financial assets, but all liabilities were included. The farmers' family living index was used as the index of purchasing power of money.

[10] Alternative estimates for livestock, crop inventories, and machinery and motor vehicles were also computed by using equation (3) and a value series in constant dollars (from [8]). Various estimates for the entire period were as follows:

	From equation (1) (billion dollars)	From equation (3)
Livestock	5.1	4.9
Machinery and motor vehicles	15.6	13.8
Crop inventories	3.9	−13.0

Estimates from constant dollar value series provide only a rough check on the results reported in Tables 1 and 2. As discussed above, the value series have shortcomings but details of methodology are not known. Therefore it is difficult to explain the discrepancy between the alternative estimates.

[11] See also [2, ch. 7].

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Hog Pricing and Evaluation Methods—Their Accuracy and Equity*

Marvin L. Hayenga

The hog-pork sector of the U. S. economy is plagued by both seasonal and cyclical price and production fluctuations. Some industry participants are now trying to alleviate the problems caused by these fluctuations by contractually coordinating some of their production—processing—distribution activities. When hog producers and meat packers negotiate a contract, an equitable pricing procedure is an essential prerequisite. In other marketing systems the pricing system is often the primary means by which producers get feedback about current consumer demands for their hogs relative to other types of hogs which they could potentially produce. This note explores the potential accuracy of a variety of live or carcass pricing or evaluation methods similar to the one examined by Ikerd and Cramer [3]. This information can be useful in comparing and selecting objective live or carcass pricing and grading systems or internal packer-buyer training and evaluation procedures. Some necessary considerations in practical application of this computerized evaluation procedure are also briefly considered.

Research Procedure

Recently, the relationships among several physical, fairly readily measurable (or estimable) live hog or carcass characteristics and the subsequent carcass wholesale values were examined. A least squares statistical analysis of 1,000 carcasses slaughtered at Michigan State University during 1960–1967 suggested (1) which live and carcass characteristics were closely related to value and (2) the degree of pricing discrimination (accuracy) within a hog population that could be expected from several hog pricing methods. The premium-discount scale that would have been appropriate if average 1963–1968 wholesale cut prices prevailed for the meat packer also was illustrated.

The sample may have been above average in terms of value and distributed within a smaller weight range (approximately 180–240 pounds) compared to the normal market population (see [6] for more detail). Nevertheless, the physical relationships found should be generally indicative of the kind of results that would be found using other samples.

The total carcass value index was derived by multiplying each wholesale product weight by its associated average price per pound. Dividing this index by either live slaughter weight or carcass weight, a live or carcass value per pound was derived which appears closely analogous to the price paid per pound in a live or carcass pricing system.[1]

Statistical Results

Certainly the most accurate pricing system would be a complete carcass cutout, weighing, and pricing procedure. Since this quite costly procedure is not generally feasible, other procedures explicitly incorporating one or more carcass measurements (or live estimates thereof) are often utilized. A quite common procedure in many direct buying stations is a purchase price based upon average live weight of the lot of hogs.

In estimating the linear relationship between carcass value per hundred pounds live weight (LVALUE) and the slaughter weight (LVSLWT) of an individual hog (equation (1)), the live weight measured to the nearest pound explained less than 9 percent of the variation in value per pound. If the actual weight of a hog was the only variable to be used in pricing hogs on a live basis, approximately one-third of the prices would have been in error by more than

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[1] Average 1963–1968 National Provisioner wholesale cut prices quotations (varying by weight of cut) were used to determine gross carcass value. Since the available cutout information did not provide a detailed breakdown on minor carcass components, some available industry and USDA statistics were averaged to evaluate that part of the carcass. To the extent that the slaughter by-product value did equal processing costs, the constant term would have to be correspondingly adjusted to provide an index of net carcass value to the packer. The slope coefficients (premium-discount scale) reflect the contribution of a change in each carcass variable (and any omitted correlated factors) to the change in value per pound; they would remain unchanged unless the difference between processing cost and by-product value was correlated with the characteristics used in pricing.

76 cents per hundredweight (at a base price of \$20 per hundredweight).

$$\text{(1)}\quad \begin{aligned} &\text{LVALUE} = 24.33 - .044\ \text{LVSLWT};\\ &R^2 = .088, \quad Sy.x = .760,\\ &\frac{Sy.x}{\bar{y}} = .038^3 \end{aligned}$$

The usual practice of pricing hogs by lot would tend to balance out some individual errors and improve pricing accuracy somewhat [2, p. 12], but the relative comparisons between pricing systems would remain approximately the same. However, the usual practice of class-pricing hogs within 20-pound weight groupings tended to reduce individual hog-pricing accuracy (R^2 =.071) in our analysis. While the usual practice of pricing hogs by lots was not specifically examined, it can be reasonably deduced that the common live-weight pricing procedures for "modern" hogs at recent wholesale prices still are quite inaccurate, as Engleman showed in 1953 [2, p. 25].

Some packers have moved toward live and carcass pricing systems that consider other factors in assigning prices to individual hogs or lots of hogs. Some packer-buyers estimate dressing percentage on a live basis or measure it in a carcass-pricing procedure. Accurate dressing percentage (DRESSPCT=(carcass weight/live weight)×100) estimates can reduce the pricing error substantially when used in conjunction with live weight measurements (see equation (2)).

$$\text{(2)}\quad \begin{aligned} &\text{LVALUE} = 7.72 - .036\ \text{LVSLWT}\\ &\qquad + .214\ \text{DRESSPCT};\\ &R^2 = .464;\\ &Sy.x = .583; \quad \frac{Sy.x}{\bar{y}} = .029 \end{aligned}$$

However, previous research results suggest that dressing percentage estimation is sometimes quite inaccurate [5]. Fat thickness has been more accurately estimated in some experiments [4]. In live pricing systems, using a live weight measurement in conjunction with a backfat estimate or probe may provide less pricing error (see equation (3)) than a system based upon live weight and dressing percentage, even though the pricing error would be less if accurate dressing percentage estimates or measurements could be made. The choice for any one packer may depend upon the relative accuracy of his buyers' estimates or the cost of the measurement that would be required.

$$\text{(3)}\quad \begin{aligned} &\text{LVALUE} = 24.62 - .013\ \text{LVSLWT}\\ &\qquad - 1.30\ \text{BFLASTL};\\ &R^2 = .275;\\ &Sy.x = .678; \quad \frac{Sy.x}{\bar{y}} = .034 \end{aligned}$$

The hog's live weight and a backfat estimate are also the primary basis for the USDA hog grading system or similar packer systems which are utilized in some live and carcass pricing systems. Usually this involves the buyer estimating the grade of the hog and adjusting the base price according to the hog's weight and grade (US 2, US 3, US 4, with US 1 as the base grade dummy variable in equation (4)).

$$\text{(4)}\quad \begin{aligned} &\text{LVALUE} = 23.49 - .015\ \text{LVSLWT}\\ &\qquad - .395\ \text{US2} - .73\ \text{US3}\\ &\qquad - 1.119\ \text{US4}; \quad R^2 = .207;\\ &Sy.x = .708; \quad \frac{Sy.x}{\bar{y}} = .035 \end{aligned}$$

Even if the buyer's grading was based upon measurements (as ours was), the pricing error would be greater in the live weight and grade pricing system than in the live weight-backfat grading system which requires the very same measures or estimates. This is primarily due to the fact that backfat thickness is an important factor affecting carcass value; lumping together individuals that vary as much as .3 inches in backfat is like discarding valuable information which could better pinpoint the value of each animal in either live or carcass pricing systems.

A fairly simple pricing procedure that gives reasonable pricing accuracy in live or carcass pricing systems utilizes one backfat measure or estimate, a carcass weight measurement, and, for the live pricing system illustrated below, a live weight measurement. Both systems provided similar fairly small errors when evaluated relative to the appropriate carcass price or live price per pound.

[3] All regression coefficients in this and subsequent equations were significantly different from zero at the .0005 level of probability. The coefficient of determination (R^2), standard error of the estimate ($Sy.x$), and the standard error divided by the mean of the dependent variable ($Sy.x/\bar{y}$) are three statistics indicating the "goodness of fit" between value per pound and the set of carcass characteristics included in the equation.

$$\text{LVALUE} = 6.57 - .020\ \text{LVSLWT} - 1.54\ \text{BFLASTL} + .235\ \text{DRESSPCT}; \quad (5)$$

$$R^2 = .724; \quad Sy.x = .419; \quad \frac{Sy.x}{\bar{y}} = .021$$

In equation (5), 72 percent of the variability in the live price is explained by the individual's live slaughter weight, dressing percentage, and a backfat measurement at the last lumbar region (which proved to be the backfat measure most closely related to value). Perhaps more meaningful is the fact that approximately two-thirds of the sample would have been priced within 42 cents of their true value, using this system, if appropriate premium-discount schedules were used.[3]

How well could you evaluate hogs without going to the cost and trouble of full cut out? When carcass measurements considered in the purebred swine associations' meat hog certification program were utilized (backfat thickness,[4] carcass length, loin eye area at the tenth rib, and carcass weight), a fairly high proportion of the carcass value variation was explained (69 percent) and the standardized pricing error index was further reduced to .017. However, the cost attached to acquiring some of these measurements (particularly the loin eye measurements, given current technology) may outweigh the benefits of the greater pricing accuracy in many situations.

[3] In the range of the major characteristics found in the sample, no significant nonlinearities were found to exist in the relationship between the carcass characteristic and carcass value per pound.

[4] The use of only one measurement at the last lumbar region was always equal or superior to the average of measurements at three different locations.

Further Implications

Many packers could make incremental pricing system improvements, often at little cost. If packers and producers recognize the long-run costs of poorly transmitting the demands of consumers through the marketing system to producers via price and allied information, they may be more willing to incur some of the short-run costs of changing the system. One would expect that producers of superior hogs would be motivated to supply those packers who use pricing systems that reward them according to value delivered. Consequently, the improved ability to regularly provide a greater supply of more desirable product (at least in the short run) to wholesale, institutional, and retail customers could provide these packers with a competitive advantage. At the same time, the likely longer-run consequence—stimulating production that better meets consumer demands—would undoubtedly enhance the long-run competitive position of the hog-pork sector in our economy.

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An Economic Interpretation of the Transportation Problem*

J. C. Hsiao

This paper solves and explains the standard transportation problem by focusing on its decentralized structure. The purpose of this focus is to emphasize an economic interpretation of the model.

Decentralized Decision-Making Structure

Given the following standard mathematical formulation:

$$(1)\qquad \min \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij}X_{ij}$$

subject to

$$(2)\qquad \sum_{j=1}^{n} X_{ij} = S_i \qquad i = 1, 2, \cdots, m$$

$$(3)\qquad \sum_{i=1}^{m} X_{ij} = d_j \qquad j = 1, 2, \cdots, n$$

$$(4)\qquad X_{ij} \geq 0 \qquad \text{all } (i, j)$$

the decentralized decision making-structure can be shown by spelling out (2) and (3) in matrix form. This is illustrated in Figure 1, where

R = unit-coefficients of X_{ij} in the supply equations;
M = unit-coefficients of X_{ij} in the demand equations.

The lower n rows represent the demand requirements for each of the n markets. The two zero-triangles indicate that there are no connections among the individual markets. The "M-boxes" stand for the n independent markets. The upper m rows, which represent quantity available from each of the m regions to each of the n markets, can be viewed as the linking constraints for all markets in the system. Note that each market or region contains different unknowns. A given variable appears in two and only two of the constraints in the whole system.[1] This decomposition-like structure, along

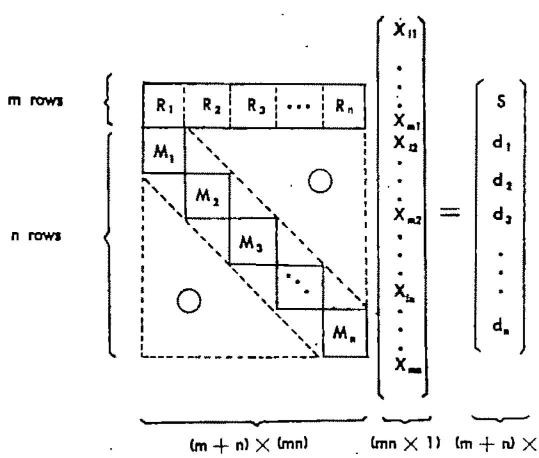

Figure 1. Decentralization structure

with prescribed solution procedures, has bee described by Dantzig [2, pp. 448–469], Simon nard [5, pp. 211–222] and Baumol and Fabia [1].

Suppose there is a market manager in eac market and no coordination among them. The each market manager's decision problem is t minimize his shipping cost and meet his ow market requirements. There are n such prob lems within this decentralized decision-makin system. However, if each of the n marke managers acts to solve his own problem, th solution obtained may not necessarily satisf the supply constraints. This is true because th transportation costs may differ among region and because every market manager, motivate by self-interest, will naturally purchase hi product from the cheapest region. Since eac market manager does not take the overall re gional goal into account, it is possible tha what is optimal for a private individual is no necessarily optimal for the whole marketin system. Two fundamental questions then arise (1) Does a competitive spatial equilibrium so lution exist in such a decentralized decision making system? (2) Would the spatial equi

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[1] For the specific case of two regions and three markets, the system can be shown as

$$\begin{array}{llllll} X_{11} + & X_{12} + & X_{13} & & & = S_1 \\ & & & X_{21} + & X_{22} + & X_{23} = S_2 \\ X_{11} + X_{21} & & & & & = d_1 \\ & X_{12} + X_{22} & & & & = d_2 \\ & & X_{13} + X_{23} & & & = d_3 \end{array}$$

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librium solution lead the decentralized decision-making market units to an optimal solution for the overall system?

Solution and Economic Interpretation

To attack this problem, we assume that a "Central Coordinating Board" (CCB) acts as a "control" device whose objective function is to minimize total transportation cost as stated in (1). Given the problem specified in (1), (2), (3), and (4), the corresponding dual linear programming problem can be written in a straightforward manner:

$$\text{(5)} \qquad \max \sum_{j=1}^{n} d_j P_j - \sum_{i=1}^{m} S_i V_i$$

$$\text{(6)} \qquad \text{subject to } P_j - V_i \leq C_{ij} \qquad \text{for all } (i, j)$$

where the P_j and V_i are dual variables and their signs are unrestricted.[2]

P_j may be viewed as the imputed market price at market j; V_i may be viewed as the value of the product free on board at region i. Inequality (6) can be rewritten as

$$\text{(7)} \qquad P_j \leq V_i + C_{ij}$$

stating that $P_j = V_i + C_{ij}$ if $X_{ij} > 0$ and $P_j \leq V_i + C_{ij}$ if $X_{ij} = 0$. That is, X_{ij} will increase as long as $P_j > V_i + C_{ij}$. The dual variables are meaningful only in the given transportation problem. Thus the replacement of CCB's objective function (1) with (5) does not change the ensuing argument with regard to the role of the dual variables.

Given the transportation cost C_{ij}, if the CCB can provide information on the value of V_i at region i, then the jth market manager's problem is to minimize the sum of value V_i paid at region i plus the shipping cost C_{ij} from i to j: that is,

$$\text{(8)} \qquad \min \sum_{i=1}^{m} (V_i + C_{ij}) X_{ij}$$

$$\text{(9)} \qquad \text{subject to } \sum_{i=1}^{m} X_{ij} = d_j$$

$$\text{(10)} \qquad \text{and all } X_{ij} \geq 0.$$

Since the sign of V_i is not restricted, it can be either positive or negative. The interpretation of V_i is economically significant and interesting. From the supplier's point of view, a positive value of V_i measures the comparative location advantage of region i; a negative value of V_i signifies the comparative location disadvantage of the region i. Thus we may call V_i the "location rent," a term which has also been used by Koopmans and Bechmann [4, p. 60]. From "society's" standpoint one could view a positive V_i as a "penalty" to market j in the sense that the market manager has to pay the extra rent charge because of the competitive demand by the other market managers. A negative V_i might be viewed as a "subsidy" to the market manager because of the location disadvantage for the particular region.

From the market manager's point of view, a positive V_i stands for an "external diseconomy of marketing." That is, if one market manager increases shipping activity from region i, there is less available from region i to other market managers who may also want to purchase from region i. Thus a positive V_i is viewed as a location rent or penalty designed to discourage the market manager's activity to region i. By contrast, a negative V_j represents an "external economy of marketing"; it means that an increase in market manager j's shipping activity from region i may release the demand pressure for the other market managers in the other regions. Therefore his shipping activity from i produces benefits, part of which devolve on other market managers. Thus a negative V_i is viewed as "subsidy" designed to encourage a market manager's activity to region i. It is interesting to note that the jth market manager's problem formulated in equation (8) does capture this basic economic behavior.

An important feature of the model just described is the way in which its information requirements are distributed. Given the transportation cost C_{ij}, each market manager needs to know only the imputed location rent or subsidy V_i and the imputed market price P_j. The information about his own market price P_j is likely to be more accessible to him than to anyone else. The value of V_i may then be looked upon as a condensation of the information issued by the CCB. The allocation of the regional production induced by this location rent is what we referred to as the solution of the transportation problem by means of the decentralized decision-making. The proposition of significance may be more rigorously stated in the form of definition and theorem.

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[2] Because the supply and demand constraints were assumed to be equal, the signs of the dual variables are unrestricted.

Definition and Theorem[3]

Definition: A set of $n+1$ vectors $(X^1, X^2, \cdots, X^n, V)$ with one vector of shipment for each market manager, $X^j=(X_{1j}, X_{2j}, \cdots, X_{mj})'$, and a vector of location rent, $V=(V_1, V_2, \cdots V_m)'$, on shipment from region i to market j, is defined as a spatial equilibrium for the spatial allocation problem, if they satisfy the relations:

(i) $\sum_{j=1}^{n} X_{ij} \leq S_i \quad i = 1, \cdots, m$

(ii) $\sum_{i=1}^{m} X_{ij} \geq d_j \quad j = 1, \cdots, n$

(iii) for each j, X^j solves the jth market manager's problem:

minimize

$$\sum_{i=1}^{m} (V_i + C_{ij})X_{ij}$$

subject to

$$\sum_{i=1}^{m} X_{ij} \geq d_j$$

and

$$X_{ij} \geq 0$$

Theorem: Given the transportation problem where mutually independent markets are recognized, there exists a spatial equilibrium solution.

Proof: For convenience in formulating the proof and to restrict the sign of V_i to be nonnegative, we rewrite the transportation problem (T) in the following form:

$$\text{(11)} \qquad \min \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij}X_{ij}$$

subject to

$$\text{(12)} \qquad -\sum_{j=1}^{n} X_{ij} \geq -S_i \qquad i = 1, \cdots, m$$

$$\text{(13)} \qquad \sum_{i=1}^{m} X_{ij} \geq d_j \qquad j = 1, \cdots, n$$

The corresponding dual problem (T') is

$$\text{(14)} \qquad \max \sum_{j=1}^{n} P_j d_j - \sum_{i=1}^{m} V_i S_i$$

subject to

$$\text{(15)} \qquad P_j - V_i \leq C_{ij} \qquad \text{for all } (i, j)$$

$$\text{(16)} \qquad P_j, V_i \geq 0 \qquad \text{for all } (i, j)$$

By assumption of $\sum S_i = \sum d_j$, the existence of a solution to (T), and hence to (T'), is guaranteed. Our assertion is that the solution will give the spatial equilibrium we defined.

Let X_{ij}^* solve (T). Then there exists (V^*, P^*) such that

$$\text{(17)} \qquad -\sum_{j=1}^{n} X_{ij}^* = -S_i \qquad \text{all } i$$

$$\text{(18)} \qquad \sum_{i=1}^{m} X_{ij}^* = d_j \qquad \text{all } j$$

$$\text{(19)} \qquad P_j^* - V_i^* \leq C_{ij} \qquad \text{all } (i, j)$$

$$\text{(20)} \qquad X_{ij}^*, V_i^*, P_j^* \geq 0 \qquad \text{all } (i, j)$$

Consider the jth market manager's problem (t_j):

$$\text{(21)} \qquad \min \sum_{i=1}^{m} (V_i^* + C_{ij})X_{ij}$$

subject to

$$\text{(22)} \qquad \sum_{i=1}^{m} X_{ij} \geq d_j \qquad \text{and}$$

$$\text{(23)} \qquad X_{ij} \geq 0 \qquad \text{all } i$$

and its dual (t_j'):

$$\text{(24)} \qquad \max P_j d_j$$

$$\text{(25)} \qquad P_j \leq V_i^* + C_{ij} \qquad \text{all } i$$

$$\text{(26)} \qquad P_j \geq 0$$

Clearly X_{ij}^* satisfies (22), (23) and P_j^* satisfies (25), (26). From (18) and duality we get

$$\text{(27)} \qquad P_j^* d_j = \sum_{i=1}^{m} P_j^* X_{ij}^*$$

[3] The statements of the definition and the theorem are basically motivated by Gale's model [3, pp. 85–93]. Although Gale's work does not provide a computational procedure, it furnishes a desired representation of the decentralized decision-making under spatial competitive conditions described in this paper. A different treatment of the transportation problem by decomposition has also been presented by Williams [6], in which a useful and more general theorem along with a computational algorithm are discussed. The proof of the theorem in this paper has benefited from the comments of a reviewer for this Journal, for which the author is most appreciative.

From (19) and duality we obtain

$$(28) \qquad P_j^* X_{ij}^* = (V_i^* + C_{ij}) X_{ij}^*$$

Summing (28) over i yields

$$(29) \qquad \sum_{i=1}^{m} P_j^* X_{ij}^* = \sum_{i=1}^{m} (V_i^* + C_{ij}) X_{ij}^*$$

From (27) and (29) we obtain

$$(30) \qquad P_j^* d_j = \sum_{i=1}^{m} (V_i^* + C_{ij}) X_{ij}^*$$

Equation (30), together with the feasibility of X_{ij}^* and P_j^* in (t_j) and (t_j') respectively, is sufficient to establish the optimality criterion.[4]

Corollary: Every spatial equilibrium for the market manager's problem solves the total transportation problem. This corollary, an immediate result from the preceding proof, is obtained by summing (30) over all j:

$$(31) \qquad \sum_{j=1}^{n} P_j^* d_j = \sum_{j=1}^{n} \sum_{i=1}^{m} (V_i^* + C_{ij}) X_{ij}^*$$

[4] See Gale [3, p. 10].

The economic content of the corollary is remarkable. It says that if a spatial equilibrium solution exists (and the theorem shows that it does), then the equilibrium forces will lead the market managers not only to solve their own problems but also to achieve the overall goal—to minimize the total transportation cost imposed by the CCB while still preserving each local market manager's autonomy.

Classical economic doctrine asserts that producers in each region act to maximize their own comparative regional advantage. It is in the interest of market managers to understand the nature of their comparative positions. The decentralized decision-making approach recognizes the interregional and intermarket competitive conditions and focuses on the economic forces to which the decentralized decision-makers respond. Of course, our discussion does not intend to elucidate how decentralized decisions are made in practice by particular area or regional economic planning. The transportation model, via decentralized decision-making may provide an alternative analytical tool which seeks to aid such decision-making processes.

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Allocation Efficiency in a Developing Agricultural Economy in Malaya*

Yukon Huang

THIS STUDY is concerned with how allocation efficiencies may change with development stages of an agricultural economy. The method of analysis involves making estimates of Cobb-Douglas production functions and intensity of input usage with respect to farm size for three paddy-growing regions in Malaya, each of which represents a different stage in development.[1] The impetus for change is the combination of irrigation facilities and quick-ripening seeds which make possible double-cropping. With these, farmers must change their cultivation techniques; in particular, higher dosages of fertilizer and more hired labor are required. Compared to the old varieties, all the new varieties being planted mature quicker and are more responsive to inorganic fertilizer, which results in higher yields. Hired labor is needed to insure that larger farms can adhere to strict planting schedules.

The three areas to be considered are in the states of Kelantan, Selangor, and Province Wellsley.[2] Kelantan lies on the East Coast of Malaya which is less developed, more rural, and culturally more Malay oriented than the more urbanized West Coast where most of the Chinese, Indians, and Europeans reside; it is a subsistence-oriented, single-cropping area where farms average 2.2 acres and yields are 215 gantangs per acre. (A gantang is a local volumetric unit and about 400 gantangs equal one ton.) The Selangor paddy district is on the West Coast and was formerly swamp and marsh land which was cleared for paddy farming during World War II. Farms here average 4.5 acres; the soil is of greater fertility; and yields are much higher, averaging 398 gangtangs per acre. Unlike in the Kelantan area, proper irrigation facilities permit double-cropping. In 1966 double-cropping had been taking place for about one year. The third area is Province Wellsley, where double-cropping has been practiced for 7–15 years. Farms here average 3.3 acres, and yields are 462 gantangs per acre. Most farmers in Selangor and Province Wellsley grow two crops a year, although in Selangor some still single-crop. In Kelantan, 69 percent of total production is retained for home consumption; 20 percent and 27 percent in Selangor and Province Wellsley, respectively.

Although yields in Selangor and Province Wellsley are relatively higher than in Kelantan, the causes are substantially different. In Selangor cultivation practices are considered poor and high yields are attributed to soil fertility; in Province Wellsley high yields are attributed to good cultivation techniques. (For example, farmers there use four or five times as much fertilizer per acre as in Selangor; and their use of hired labor and tractors and better transplanting methods result in a shorter season.)

One could thus hypothesize that allocation efficiencies may differ among the three areas. Logically one would expect some allocation inefficiencies in transitional Selangor where farmers must get used to a new technology and adjust input usage accordingly. If one believes commercially oriented farmers to be economically efficient, allocation inefficiencies should be less in Province Wellsley. Whether inefficiencies should be expected in Kelantan depends upon one's hypothesis about the behavior of subsistence farmers. Elsewhere [3] the author advances several reasons why inefficiencies may exist in the subsistence area, along with some empirical verification.

Data

Data for this study were available from questionnaires as recorded by the Malaysian

* I am indebted to the editors and two anonymous referees for their helpful comments and to W. Arthur Lewis and Charles Frank, Jr. for their guidance during the writing of my dissertation. This note is a revised version of one section.

[1] The statistical problems that may exist have been pointed out, but in general data limitations and the problems involved with more sophisticated methods have made most scholars resort to single-equation least squares methods in estimating Cobb-Douglas production functions. Given certain assumptions that may hold for a peasant economy, consistent and unbiased estimates are possible (see [4, pp. 38–39]). At any rate all such findings must be qualified and used only as supporting, not conclusive, evidence. For earlier work on allocative efficiency in traditional agriculture, see [2, 5, 9].

[2] All data in this paragraph come from [6, 7, 8].

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Ministry of Agriculture and Cooperatives. A random sample of farmers was selected from a much larger random sample obtained annually by the Department of Statistics. Enumerators spent several months recording information on production and inputs and observing techniques. Surveys were taken during 1965–1968 and summaries were published [6, 7, 8]. For our purposes the data were disaggregated, using the original questionnaires. Several spot checks on accuracy were conducted, since enumerators depended primarily on farmers' statements. While no exact indications of accuracy are possible, spot checks indicated that production, cash inputs, and area cultivated were accurately reported. Data on family labor used were probably less reliable since it is difficult to measure the amount, much less the quality, of family labor, especially in a relatively backward agricultural economy. For more information on the quality and origin of the data see [3].

Empirical Findings

To see whether allocation efficiencies differed among the areas, Cobb-Douglas production functions $Y=f(A, V, FL, HL)$ were estimated, where

Y = total production of paddy in a year in gantangs (400 gantangs = 1 ton)
A = total area cultivated per year (acres)
V = total variable inputs utilized per year (fertilizer, insecticide, and seed expenditure, in Malaysian dollars)
FL = total family labor utilized per year (man-hours)
HL = total hired labor utilized per year (Malaysian dollars).

The relationships of the marginal productivities derived from the production functions to opportunity costs (market prices) for the inputs give an indication of allocation efficiencies. If the ratio is greater (less) than unity, more (less) of that input should be used. The results are presented in Table 1. As hypothesized, allocation inefficiencies are most prevalent in transitional Selangor and evidently nonexistent in commercialized Province Wellsley. Some allocation inefficiencies appear to exist in Kelantan. The evidence indicates that allocation inefficiencies are the greatest in Selangor where farmers have not yet had time to adjust to the new technology and as a result are not using enough variable inputs, hired labor, or land. The inefficiency in use of land may be due to abnormally low rentals. The onset of double-cropping usually raises rental rates and landowners may not have had enough time to raise charges. Use of the wage rate for contract labor probably overstates the opportunity cost for family labor and the indicated inefficiency is perhaps illusory. In Kelantan inefficiencies are much less, but perhaps more variable inputs and hired help are needed. In the commercialized area of Province Wellsley, where the farmers have had ample time to adopt the new

Table 1. Cobb-Douglas production function estimates for three areas of Malaya

	Areas of Malaya		
	Kelantan	Selangor	Province Wellsley
Estimated coefficients			
Constant term (C)	1.967 (2.622)[a]	5.090 (17.494)	3.982 (6.593)
Land area (A)	0.325 (2.220)	0.831 (9.198)	0.560 (3.981)
Variable inputs (V)	0.186 (2.921)	0.091 (2.243)	0.153 (1.988)
Family labor (FL)	0.491 (3.925)	0.112 (2.575)	0.092 (1.717)
Hired labor (HL)	0.073 (2.513)	0.044 (3.990)	0.249 (3.092)
Sum of coefficients	1.075	1.078	1.054
Number of observations	84	76	62
R^2	.692	.866	.897
Geometric means			
Output (gantangs)[b]	419	3,410	2,410
A (dollars)	2.08	7.93	5.61
V (dollars)	21.50	27.20	123.00
FL (man-hours)	556	1,860	673
HL (dollars)	8.99	59.60	418.00
Marginal products			
A (gantangs per acre)	65.49	357.47	241.00
V (gantangs per dollar)	3.63	11.45	3.00
FL (gantangs per man-hour)	.37	.21	.33
HL (gantangs per dollar)	3.39	2.52	1.43
Ratio of marginal productivity to opportunity cost[c]			
A	0.60*	2.66*	1.35
V	2.32**	7.33**	1.92
FL	0.96	0.54*	0.68
HL	2.17*	1.61***	0.92

[a] Figures in parentheses are t values.
[b] 400 gantangs = 1 ton.
[c] The significance of the ratios was determined by using the formula given in (1).
* Significantly different from unity at .05 level.
** Significantly different from unity at .10 level.
*** Significantly different from unity at .20 level.

technology of double-cropping, inefficiencies are the least.

As further support for these findings we examined the intensity of input use with respect to farm size. The following model was used:

$$\log(\text{input}) = a + b \log(\text{paddy area cultivated})$$

The estimated coefficient (b) is an elasticity of the input use with respect to farm size. If the elasticity is less (greater) than unity, the intensity of input use per farm area declines (increases) as farm size increases. Estimated elasticities for Kelantan were 0.887, 0.839, and 0.262 for family labor, variable inputs, and hired labor, respectively. For Selangor the comparable elasticities were 0.750, 1.227, and 1.989; for Province Wellsley they were 0.582, 1.067, and 1.056. In all cases the estimated coefficients were highly significant at the 99 percent level. In Kelantan the elasticities are all below unity, indicating that farmers do not maintain their intensity of input use as farm size increases. In Selangor the elasticities of hired labor and variable inputs are above unity, supporting the hypothesis that the larger farms may respond sooner to the demands of double-cropping than the smaller ones and thus have higher intensities of input use. In Province Wellsley the elasticities of hired labor and variable inputs are close to unity, supporting the hypothesis that given enough time the farmers will learn the proper intensity of input use and maintain it as farm size increases. In all three areas the elasticity of family labor is lower than unity, as expected.

The intensity of input use manifests itself in yields. Regressions of yield on farm size indicated that yields fell with increasing farm size in Kelantan but increased with farm size in Selangor. In Province Wellsley yields were constant over farm size.

Our Cobb-Douglas estimates indicated that allocation inefficiencies existed mostly in the transition from a subsistence-oriented economy to a double-cropping commercially oriented economy. Given enough time, allocation inefficiencies disappear as farmers appear to be responding to the commercial possibilities of double-cropping and allocating their resources efficiently.

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Resource Productivity in Indian Agriculture*

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RECENT ARTICLES by Hayami and Ruttan [10] and Hayami [9] have used a "meta-production function" to account for differences in agricultural labor productivity between developed countries and less developed countries. The meta-production function is regarded as an envelope of existing agricultural production functions and is only potentially available to producers in a particular country or agricultural region during a particular period. It is of interest to contrast the meta-production function with the production functions actually existing in several situations.

This note reports estimates of the aggregate production function for India's agriculture and compares these with the Hayami meta-production function estimates, with the studies by Griliches for the United States [7, 8] and with a district-level analysis for India by D. P. Chaudhri [2]. Our results, along with Chaudhri's, indicate a much smaller effect of education on agricultural production in India than in the United States or in a cross section of countries.

The units of observation are the 16 states of India. Data for two agricultural years, 1960–61 and 1964–65, are analyzed in a parallel way, the results compared, and then compared with the other studies.

Definition of Variables

The total value of agricultural production for each state was obtained by taking total reported production of the 24 principal crops times the reported 1960–61 farm harvest price in each state.[1] In those states for which no price was reported the average price in all other states was used. The total value of output for 1964–65 was calculated in the same way, using 1960–61 prices. Weather in 1960–61 was about average, while 1964–65 was a year of exceptionally favorable weather [1]. Thus one might reasonably interpret differences in resource productivity between the two years as differential reaction to weather conditions.

The resources used in Indian agriculture may be classified as (1) land and labor; (2) "traditional" capital inputs, like irrigation, draft animals, and hand tools; and (3) "modern" capital inputs, like fertilizer and powered irrigation pumps. Each class of inputs was reflected in several variables. Land was measured as the total cropped area reported in the annual land utilization statistics. This counts double-cropped land twice but also includes planted acreage that may not have been harvested because of crop failure. Irrigation was measured as the total area of land irrigated from all sources.

Labor was measured as the stock of "agricultural laborers" plus "cultivators" as recorded in the 1961 census. Labor in 1964–65 was assumed to be the same proportion of total population as in 1961[2] and was derived from the official mid-year estimates of population of each state. Since this procedure cannot reflect possible shifts of labor out of agriculture, the 1965 data may be biased to the extent that nonfarm jobs were created at different rates in different states.

Traditional capital inputs include draft cattle, animal-drawn carts, and dug wells. Nontraditional capital inputs are represented by the number of diesel and electric irrigation pumps. Livestock numbers, wells, and pumps were obtained from the livestock census, taken every five years, in 1961 and 1966. The 1966 data were used for 1964–65 in this study. Data on fertilizer distributed to each state are available on a crop-year basis; but since the data are for distribution rather than actual use, they may have some bias due to changing inventory levels. Fertilizer was measured as the total nutrient tons of $N+P_2O_5+K_2O$. The impact of education may be reflected in any number of variables. Two alternatives were used here: the literacy rate in one equation and the number of

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[1] Data were obtained from [3], [4], [5], and [6].

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[2] This is a reasonable assumption in light of the fact that the proportion of the population in the classes of agricultural laborers and cultivators was virtually constant between 1951 and 1961 [6].

Table 1. Zero-order correlation matrix, logs of variables

	Land	Labor	Draft cattle	Carts	Irri-gation	Pumps	Ferti-lizer	Liter-acy	Extension workers
1960–61									
Land	1.0								
Labor	.86	1.0							
Draft cattle	.81	.95	1.0						
Carts	.83	.95	.99	1.0					
Irrigation	.39	.55	.53	.51	1.0				
Pumps	.37	.35	.19	.21	.26	1.0			
Fertilizer	.54	.67	.52	.51	.54	.76	1.0		
Literacy	−.38	−.42	−.49	−.48	−.33	.25	.13	1.0	
Extension workers	.46	.76	.82	.80	.70	−.08	.37	−.53	1.0
1964–65									
Land	1.0								
Labor	.86	1.0							
Draft cattle	.83	.96	1.0						
Carts	.84	.96	.99	1.0					
Irrigation	.37	.48	.54	.53	1.0				
Pumps	.28	.25	.12	.13	.13	1.0			
Fertilizer	.43	.47	.35	.34	.47	.86	1.0		
Literacy	−.17	−.19	−.23	−.28	−.01	.34	.30	1.0	
Extension workers	.78	.96	.95	.94	.54	.17	.84	−.19	1.0

extension workers assigned per state in a second equation.

The Analysis

Table 1 presents the zero-order correlation matrices for the logarithms of the above variables for 1961 and 1965. It shows that labor, draft cattle, and carts are one group of highly intercorrelated inputs. Even though all these inputs are required in Indian agriculture, and therefore one would like to know their productivity individually, as commonly happens when variables are highly intercorrelated, inclusion of all three resulted in estimates with extremely high standard errors. Further, their high correlation indicates that these inputs are combined in nearly fixed proportions under conditions prevalent in India. Therefore draft cattle and carts are omitted from the functions presented here, with the result that the coefficient of labor includes the contribution of those inputs as well.

Log-linear production functions were fitted to the data with the results shown in Table 2. The first pair of equations include land, labor, irrigation, fertilizer, and power pumps. In suc-

Table 2. Estimated aggregate production elasticities for agriculture, India

Input	61-1	65-1	61-2	65-2	61-3	65-3
Land	0.358 (0.333)	0.312* (0.161)	0.309 (0.273)	0.046 (0.153)	0.397 (0.304)	0.167 (0.178)
Labor	0.231 (0.362)	0.401** (0.163)	0.277 (0.301)	0.603** (0.176)		
Irrigated area	0.329 (0.179)	0.152** (0.076)	0.325 (0.169)	0.230** (0.085)	0.354 (0.347)	0.623** (0.214)
Power pumps	−0.036 (0.124)	−0.194** (0.073)				
Fertilizer	0.137 (0.177)	0.503** (0.141)	0.093 (0.088)	0.170** (0.075)	0.143 (0.095)	0.229** (0.088)
R^2	.85	.97	.85	.95	.79	.93
Sum of coefficients	1.019	1.174	1.004	1.049	0.894	1.019

* Indicates significance at the 95 percent level.
** Indicates significance at the 95 percent level.

ceeding equations, first power pumps and then labor were omitted. None of the production elasticities estimated from the 1961 data was significant, while all the 1965 equations had at least two significant coefficients. On the other hand, each of the 1965 equations can be criticized for one reason or another. On balance it appears that, in spite of the negative coefficient for power pumps, the first pair of equations are as reliable as can be obtained with these data.

While only the analysis for 1965 results in significant production elasticities, it may still be interesting to contrast the estimates of the first equation for the two years. The productivity of land is about the same in both years, but the productivity of labor and of fertilizer are substantially higher and the productivity of irrigated land considerably lower in the year of better weather. These seem to be reasonable results since good weather will complement labor and fertilizer, increasing their productivity; at the same time, by substituting for irrigation, good weather will raise output in nonirrigated states and thereby depress the apparent productivity of irrigation.

The significant negative elasticity of power pumps in 1965 could have the same explanation. The weather may have been so favorable for nonirrigated production that the states with relatively few power pumps had relatively greater production than those with more pumps.

Comparison with Other Studies

A comparison of our 1965[3] results with those of Chaudhri, Griliches, and Hayami[4] shows more differences than similarities, even recognizing that the comparison must be inferential at best because of the different inputs used in the studies. In the left half of Table 3 our study is contrasted with Griliches' and Hayami's estimates without education variables.

The differences in the production elasticity of fertilizer in the three studies conforms with a priori reasoning that the productivity of fertilizer would be small in a country like the United States, which uses large quantities, intermediate across 38 countries in which the range of use was fairly wide, and quite high in India where per acre application rates were very low in 1965.

The same reasoning would argue for low productivity of labor in India, with its productivity increasing to high in the United States; and the ranking of the labor coefficients follows this order, although the differences are much smaller than in the case of fertilizer. Land has a much higher productivity in India than in the other studies.

Impact of Education

Griliches, Hayami, and Chaudhri all emphasize the importance of education for increasing the productivity of agriculture. Hayami concludes that "India can double her agricultural production only by improving education to its present level in Japan" [9, p. 574]. Chaudhri's study of district data revealed a small significant effect of education on production, although he did not present estimates for functions excluding education.

Two variables were used in this study to determine the effect of education on Indian agriculture. General education as reflected in the literacy rate was included in equation 1965A, and agricultural extension education as reflected in the number of village-level workers was included in equation 1965B. The estimated coefficient of the literacy rate is negative and barely significant, while the coefficient of village-level workers is negative but not significantly different from zero (at the 95 percent level). In Chaudhri's study, four alternative measures of education all had small ($<.1$) but significant positive coefficients. Thus, the two studies for India show that education has a very small production impact on India's agriculture.[5] This contrasts with education coefficients ranging between .3 and .4 for the United States and intercountry studies.

Setting aside for a moment the inadequacies of the measurement and analysis, very small production elasticities for education might seem to imply that India does not lie on the Hayami-Ruttan meta-production function and that education is not an important factor for increasing agricultural production in India.

[3] Because of the lack of statistically significant coefficients for 1961, those estimates are omitted from the comparison with the other studies.

[4] We examined the results of Hayami's 1969 study, which included only one education variable, to make comparison with Chaudhri's and with our study more direct. The inclusion of a variable reflecting technical agricultural education in the Hayami-Ruttan paper of 1971 [10] has relatively little impact on the other estimated coefficients in their study.

[5] It is interesting that Herberger found that the rate of return to education in India during the late 1950's was somewhat below the rate of return to capital investment for the same period [11].

Table 3. Comparisons of aggregate agricultural production elasticities

	Functions excluding education				Functions including education					
	India 1965A	United States [7][a]	United States [8]	World [9]	India 1965B[b]	India 1965C[b]	India [2]	United States [7]	United States [8]	World [9]
Land	.312 (.161)[c]	.170 (.033)	.152 (.022)	.176 (.058)	.357 (.146)	.308 (.164)	.606[d] (.044)	.167 (.032)	.146 (.022)	.217 (.053)
Labor	.401 (.163)	.449 (.072)	.426 (.051)	.425 (.059)	.264 (.163)	.556 (.270)	−.043 (.047)	.524 (.076)	.511 (.060)	.455 (.066)
Irrigated area	.152 (.076)				.118 (.070)	.168 (.080)	.135 (.015)			
Fertilizer	.503 (.141)		.107 (.012)	.170 (.057)	.686 (.159)	.508 (.144)	.089 (.015)		.100 (.013)	.180 (.056)
Machinery[e]	−.194 (.074)	.359 (.048)	.200 (.046)	.186 (.058)	−.232 (.069)	−.198 (.076)		.325 (.049)	.158 (.037)	.111 (.055)
Livestock expense		.169 (.023)						.140 (.025)		
Other current expenses			.121 (.032)	.393 (.024)				.111 (.031)	.367 (.028)	
Buildings			.094 (.044)					.075 (.042)		
Rainfall							.373 (.051)			
Education					−.371 (.196)	−.209 (.288)	.073 (.038)	.431 (.181)	.405 (.161)	.335 (.190)
Sum of coefficient[f]	1.174	1.362	1.278	.957	1.193	1.342	1.155	1.352	1.282	.963
R^2	.97	.98	.98	.94	.98	.97	.79	.98	.98	.98

[a] Numbers in brackets are references to the studies quoted.
[b] In equation 1965B education is reflected in the literacy rate while in equation 1965C education is reflected in the number of VLW's in position in the state.
[c] Standard errors in parentheses.
[d] Unirrigated land only.
[e] Power pumps in India.
[f] Excluding education.

This suggests either that India is very different from other countries (a unique case) or that the relationship between education and high productivity in other countries has been incorrectly diagnosed. It is possible that education is a consumption good that is a result of rather than a cause of high levels of agricultural production; but if this is true, there remains no consistent theory explaining the very wide differences in agricultural productivity among countries. Since a unique case seems highly unlikely and the education theory is quite convincing, one could conclude that India does lie on the Hayami-Ruttan meta-production function and that the small estimated impact of education on India's agriculture has another explanation. Traditional agriculture is characterized by stability, unchanging technology, and production techniques that are easily passed from one generation to the next. Formal education in India has placed little emphasis on problem solving. Under these conditions, which still hold for much of India, it is difficult to see how formal education could have much impact on production. Only when technology changes rapidly and becomes increasingly complex so that new facts and techniques are continually available does education become important to production. And perhaps equally important, only when an education that views technology as a means to problem solving becomes widespread will rapidly changing technology be built into the system. Thus there is a distinct complementarity between education and technological complexity.

Given this complementarity, empirical stud-

ies would result in a large coefficient for education if there were a wide range in technological complexity among the units of observation and a small coefficient if there were a narrow range in technological complexity, ceteris paribus. It is clear that the Hayami analysis of 38 countries encompassed a wide range of technological complexity, and the same is probably true of the 65 U. S. regions in Griliches' study. The range of technological complexity among the 256 districts in Chaudhri's study is wider than among the 16 states in the present study, if only because of aggregation effects.

Viewed in the context of complementarity between education and technological complexity, the results for India are not inconsistent with Hayami's and Griliches' and in fact support Hayami's speculation about the relationship between conventional and nonconventional inputs [9, p. 574]. However, at the present time the rather uniform simplicity of technology in India's agriculture results in little direct effect of education on agricultural production. Until India's agriculture is transformed to a much greater degree, productivity differences will depend upon land, labor, irrigation, and fertilizer.

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EDITOR'S NOTE: This section of the *American Journal of Agricultural Economics* may include comments on the replies to previous articles and other literature in agricultural economics, suggestions for improving the effectiveness of the AAEA, discussions of changes in emphasis needed within the profession, and contributions on other topics of interest and importance to agricultural economists. Manuscripts submitted for this section should be prepared in accordance with the guide appearing on the inside of the back cover of this issue and should not exceed 1,000 words.

Communications

TOLLEY AND MANAGEMENT: UNRELIABLE RESIDUAL RETURNS AND NONIMPUTABLE COSTS

Tolley's examination of management entry into farming [3] is a heroic effort to draw needed conclusions about an important subject. Despite its impressive credentials, the analysis is built upon doubtful assumptions, inapplicable techniques, and unreliable data. It also fails to handle expertly the concept of efficiency and how it relates to the management factor in farming. Further, the more reliable findings are not entirely new.

This comment, though critical, is not unsympathetic. Skilled management is indeed a vital factor in modern farming, and the economics of its entry and exit affects the farm economy as well as the career welfare of entering and exiting individuals.

Tolley runs into two problems. The first is conceptual: the meaning of efficiency. Estimation of efficiency in farming is indeed slippery. A gross measure puts aggregate output in the numerator and resources in the denominator. Resources must include management. Yet management's role is to manipulate the other resources and its quality or quantity is expressed in terms of its effectiveness in doing so.[1] Any gross efficiency calculation is manifestly circular.

How often in literature is this issue ducked! Either management is implicitly blanketed into the labor factor or, in a kind of egalitarianism, is imputed as a standard value—so that a farm is efficient if its "net return to management" exceeds a target figure, or less so if it falls short.

Tolley performs a service in reminding that quality of management varies widely. It would have been better if he had developed the idea instead of perpetuating previous misunderstandings. He even quotes, early in his article, a line that is either meaningless or tautological, that "efficient farm sizes are above most in existence" [3, p. 485].

The second problem is analytical. Here Tolley runs into an impenetrable roadblock. Farming yields joint returns to combined factors. To isolate the management factor, only two techniques are theoretically possible; and one is the obverse of the other: to attach objective values to output and the other three inputs and derive returns to management as a residual, then comparing it with its opportunity value in other employment; or to impute an objective value specifically to management.

Both are fraught with error. The residual value approach funnels all errors and omissions into the residual figure. It is impossible empirically to encompass either all output or all resources into a single aggregate production function and measure them accurately. A residual return to one claimant, as so derived, has a big error term.

There ought to be a law against attributing residual returns to one's favorite beneficiary, be that education, or management, or the political party in power.

Tolley's analysis, for example, omits capital gains as a return in farming. During the period studied capital gains affected farmers' career choices.

It is even more difficult to estimate an opportunity value for management or to impute any objective value to it. The ERS tried to attach a value to quality of management when it struggled valiantly with these same problems in its Parity Returns report; its figure of $2.86 an hour for Class I farmers is far too low [4, p. 17].

Yet Tolley tries to do the impossible, first deriving residual return to management in farming, then "valuing factor inputs at alternative earnings" [3, p. 488]. He gets his alternative earnings by applying arbitrary corrections to the residual returns. It is not only a circular process but a guesswork one. As though to elaborate the mistake, the guesses he uses are opposite to his general judgment arrived at earlier in the paper. For his calculations he assumes that returns to management of larger farms equate with nonfarm opportunities, but to smaller farms are only two-thirds of "potential nonfarm earnings" [3, p. 490]. Previously, he had viewed low-level veteran farm managers as specialized and lacking good outside opportunities.

[1] For a good review of the subject see [2].

Faulty census data. Tolley uses census data in his study. Census figures on sales and expenditures on farms are notoriously bad. Even Tolley doctors them before putting them into his equations.

Farm entrants. Tolley's cohort analysis of farm entrants is unchallengeable. He finds that newly appearing farms selling $10,000 or more of products in 1964 did not come solely from cohorts of farmers who expanded as they got older. A substantial number came from younger entrants who started at that size. In other words, the agricultural ladder is not operative. True, but hardly news (cf., e.g., [1]).

Subjective judgments. Tolley offers subjective judgments and not analytical findings. What in fact is happening? My own guess is that the higher grade managers in agriculture are the more likely to earn substandard incomes and the lower grade ones are closer to parity of returns. The best managers on Missouri farms are indeed excellent and could perform well in any nonfarm business. The ordinary farmers in Missouri would be ordinary workers anywhere.

Tolley thinks that all agriculture will drift into the hands of the higher-grade managers. Perhaps so. But he seems to be hard put to explain the continued entry of a sizable number of young small farmers. If he lived in a part-time farming area he would not be surprised, nor so sure of his conclusions. One of the reasons part-time farmers may gain a tight foothold is conspicuously absent in Tolley's analysis. It is the tax advantage of being able to share living and farm-business costs. (Tax rules affect the "efficiency" of big farmers too.)

General welfare. One of the soundest observations Tolley makes is that "human capital replacement makes a greater contribution to change in farm numbers than to change in aggregate efficiency measure" [3, p. 489]. Bravo! Some of us have long argued that playing the farm-numbers game has little relation to the macroeconomics of agriculture but is a life-or-death matter to thousands or millions of farmers and their families.

Back to the policy question: We do not know how to calibrate the quality of farm managers. If we do so by residual returns to management, we engage in tautology. We have no reliable data on nonfarm income equivalents. We can only guess, and Tolley makes two different guesses.

But ought all farming to be put in the hands of the higher-grade operators? If farmers' management skills vary over a wide spectrum, should not farming accommodate them?[3] One of the beauties of farming is that it offers an infinite number of management combinations. There may indeed be one combination for each skill of farmer. Farming may not be the place for enforced egalitarianism; it may, in the public interest, be viewed as a place where varying enterprise combinations can be equally hospitable to the quiet and the aggressive, the dull and the imaginative, the young and the old. Net returns will inevitably cover a wide range. Would that be bad?

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[3] In this respect it is unfortunate that Tolley's analysis used $10,000 sales as the cutoff for large farms. For purposes of his study the figure is unrealistically low. The fault is not his; the data did not permit a higher threshold.

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REPLY TO BREIMYER ON MANAGEMENT

Breimyer and I are together in believing that greater recognition is needed of management differences. He accepts the cohort evidence that higher-quality is replacing lower-quality human capital. He agrees that career choices differ according to age and ability. Since the purpose was to show how age and ability explain recent adjustments, nothing important in the article is at stake.

Most of Breimyer's comments concern efficiency indexes. A minor part of the article used an efficiency index to estimate how much the retirement of low-level management is contributing to raising output per unit of input. Low-level managers appear to be producing less than if they had entered nonfarming and can be viewed as earning negative quasi-rents. As they pass out of farming, the human capital replacing them is deployed so as to earn a more normal return. A greater amount of product from a given amount of human capital inputs is obtained. The effect of this greater product on an index of output per unit for agriculture was found to be small.

Breimyer is bothered about nonfarming earnings. He claims that to assume in one place that nonfarm earnings are greater than in farming for persons with low-level management ability is opposite to an earlier judgment that they are specialized and lack good opportunities. For the efficiency index, an estimate is needed of returns to people outside of farming from the beginning of their careers. Even though low-level managers could be earning more if they had started

off in nonfarm occupations, the gains are not sufficient to justify an occupational change after a few years in farming. By this time they have acquired specialized knowledge, and the cost of learning a new trade has risen because they are older. Contrary to Breimyer's claim, there is nothing inconsistent between assuming that they could have earned more in nonfarming and assuming that they are now too specialized to change.

He speculates in passing that managers who are worst off relative to nonfarm alternatives are those in high-output farms. Why is high-level management streaming into agriculture? Why is low-level management streaming out intergenerationally at an unprecedented rate?

But let virtually any assumptions or guesses be made about nonfarm earnings. The conclusion about smallness of effect on output per unit of input will be the same.

Aside from this detail, Breimyer's statements about management and efficiency seem to be asking how to measure human capital. A useful measure of the amount of human capital of a person is the value of his marginal product in a base year. In the measure there is nothing mysterious about the person's marginal product; it is the amount by which the output of the economy would fall if the person stopped working. Breimyer worries because "management's role is to manipulate the other resources," as if this role sets management apart intrinsically. But why the worry? Every resource has special intrinsic qualities. We can still talk about marginal products.

The article could have been written using, instead of the convenient term management, the phrase human capital of different qualities. For some purposes, a useful approach giving management a separate identity could be to define management return as the product of the manager above the return to his raw labor. The management factor could then be "isolated" and would not be "implicitly blanketed into the labor factor."

"Any gross efficiency measure is manifestly circular," and "it is impossible empirically to encompass either all output or all resources into a single aggregate production function," and "there ought to be a law against attributing residual returns to one's favorite beneficiary" are aimed at a body of research tangential to the article. Since factor returns add up to total product, returns to one particular factor can be measured by subtracting returns to all other factors from total product. Another possibility is to measure returns to all factors, in which case there is likely to be a statistical discrepancy. If prices and quantities of the product and factors can be estimated, comparisons can be made of physical changes in outputs and factor inputs over time. Most indexes of output per unit of input are concerned with such comparisons. One can go further and try to explain changes in output not accounted for by the economically rewarded factor inputs. There may be economies of scale, or nonpriced inputs such as generally available knowledge may increase. All this is well-known and is the basis of vast empirical work not subject to the charges that it is "circular" or "runs into an impenetrable roadblock" or is "impossible."

A reply to Breimyer's criticism of the use of census data is that census data are not good but are just the best available. In the article shortcomings of the census data were confronted in detail. Vague remarks about inadequacies of census data are not a serious challenge.

True, census data do not indicate why there is a somewhat greater-than-expected number of entering farms with low sales. Breimyer suggests only that people may engage in low-sales farming for tax reasons. Other reasons for low sales in nonpoverty situations are transitory events, e.g., disease or low sales during start-up of a large operation. One can counter with examples of poor young farmers in eastern and southern mountains who have worked in Detroit but have become discouraged and returned to eking out with a patch of tobacco and little else. Need for survey research on entering low-sales farms was pointed out.

The econometric estimates in the article indicate relative responses to income, taking account of all income sources. If capital gains attract farm managers, this income source is included and not omitted, as Breimyer claims. Capital gains are a return to ownership, not to management. Joint economies in ownership and management have to be analyzed to find out whether capital gains really attract farm managers.

The existence of capital gains is favorable to the suggestion policy of setting supports for high-level managers at long-run equilibrium levels, with greater supports for low-level managers on small farms gradually passing out of existence. Switching to that policy could in some circumstances have adverse land value effects leading to opposition or to demands for compensation for the loss in land value. In a time when land values are rising rapidly for nonprogram reasons, the adverse effects might not even be noticed.

Breimyer hints at a policy disagreement but is not specific. He asks, "If farmers' management skills vary over a wide spectrum, should not farming accommodate them?" The suggested policy would allow a wide spectrum. What more does he have in mind? Attempting deliberately to keep people on the farm who have no comparative advantage there would go beyond present policies. Whether present policies are speeding up or slowing down the exit of low-level managers is unclear. It is doubtful whether the suggested policy or any policy would much affect their rate of exit.

Nor is the number of high-level managers very amenable to being influenced if production is to be kept somewhere near market demand. Less surplus production would mean fewer high-level managers,

but the overall distribution of management abilities in agriculture would probably not be much affected by switching to the suggested policy.

The major change would be in program restrictions and expense. Present policies give a misleading invitation, making high-level managers wish to enter at too high a rate relative to growth of product demand. Needs for controls and for treasury payments not to produce are perpetuated. The suggested policy could lessen these needs without harm to managers in agriculture.

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MONTHLY SUPPLY-DEMAND RELATIONSHIPS FOR FED CATTLE AND HOGS: COMMENT

Hayenga and Hacklander [1] have argued that pork is a substitute for beef but that beef is complementary with pork. That is, the American consumer has become saturated with beef and will consume more beef only if he can consume more pork. On the other hand, he is willing to give up some beef consumption in order to consume more pork. They were placed in the awkward position of making this argument in trying to defend the divergent signs of the beef-on-pork (>0) and the pork-on-beef (<0) price flexibilities estimated in their model. The implications of their argument are not consistent with observed data.[1]

Consider what they are telling us about the shape of the indifference curve between beef and pork for the average American consumer. More importantly, consider the position of equilibrium they are depicting. For their conclusions to hold, the indifference curve for the typical consumer must be shaped like the one in Figure 1.[2] Moreover, the equilibrium position of the consumer must be point A for their argument to hold. Point A is the *only* point on the indifference curve that can give rise to the divergent signs on the beef-on-pork and pork-on-beef price flexibilities that Hayenga and Hacklander present in equations (1a) and (2a) [1, pp. 538–539]. At point A the consumer has become saturated with beef (its marginal utility is zero) and will consume additional quantities only if he can simultaneously increase pork consumption. However, the consumer is willing to give up some of his current beef consumption in order to consume more pork, ceteris paribus.

If the equilibrium position of the consumer were at point A, as the coefficients of their model indicate, the price of beef would be zero. This implication is strongly at odds with the following observations: (a) Beef prices have been at near record high levels in recent years; (b) consumers have increased their consumption of beef during this period of high and rising prices; and (c) the ratio of per capita beef consumption to pork consumption has increased from 1:1 in 1947 to 2:1 in 1968. A positive price for beef is totally inconsistent with their argument.

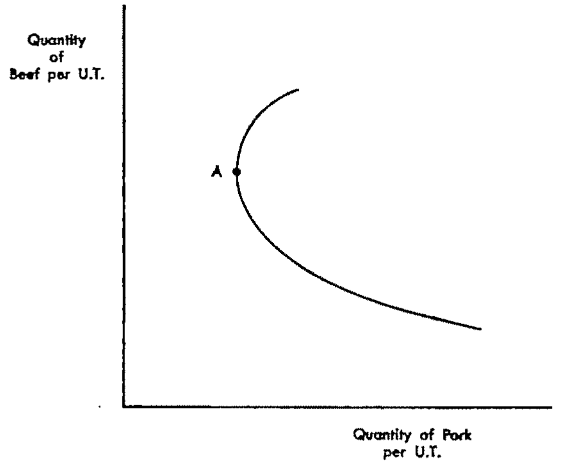

Figure 1. Indifference curve between beef and pork and point of equilibrium implied by Hayenga and Hacklander

Hayenga and Hacklander suggest that at the current ratio of two pounds of beef consumed for each pound of pork consumed, the American consumer has reached the point where "total beef consumption may not increase without a corresponding increase in the demand for other meats, especially pork" [1, p. 539]. Even if 2:1 is the ratio at which the consumer is no longer willing to consume more beef without also increasing pork consumption, the positive cross-price flexibility they obtained in equation (2b) is an average coefficient for the entire 1963–1968 period. It does not pertain to the end point of the period. Hence, their results imply that the equilibrium position of the typical consumer has been on average at point A during the period. For their conclusion to be consistent with observed data, the ratio of beef consumption to pork consumption would have had to decrease over this period, or at most remain constant. We observe it doubling.

At a later point in the paper they cite Lancaster [3] to support their results. Lancaster reformulates demand theory based on a utility function that has

[1] Other comments I made on the original manuscript were adequately accounted for. However, the main criticism I had of the paper was not corrected; namely that divergent signs on the cross-price flexibilities between beef and pork are an unacceptable result. The comments that follow were included in my review of the paper.

[2] Compare the indifference curve depicted in Figure 1 with Waugh's estimate of the indifference curve between beef and pork [4, pp. 53–56].

characteristics of goods rather than the goods themselves as arguments of the function. He is quoted as follows: "Many goods within a commodity group will have relationships to each other which are partly complementary and partly substitution."[3] His next two sentences, not quoted, are: "This will be true if two goods [beef and pork], for example, are used in different combinations in each of several activities [types of meals], each activity giving rise to a similar set of characteristics. The goods are complements within each activity, but the activities are substitutes" [3, p. 144–145]. Beef and pork are not consumed in the same meal as a general rule. There are of course some exceptions, such as combination meat products (10 percent or less of total meat consumption). Therefore, the A matrix (using Lancaster's terminology) consists primarily of vectors for which, if $a_{by_i}>0$, $a_{py_i}=0$. That is, if beef is consumed in activity y_i pork is not consumed. Given such a structure of the consumption technology, if the activities are substitutes the goods will also be substitutes.

It is theoretically possible for the cross-price elasticities (flexibilities)[4] to diverge in sign and the indifference curve to be downward sloping. However, this requires the income effect of a change in the price (consumption) of beef to be extremely large. This follows from the condition that the Slutsky substitution terms are equal. Hence it can be shown that

$$E_{bp} = \frac{W_p}{W_b} E_{pb} + W_p(E_p - E_b)$$

where

E_{bp} and E_{pb} are the cross-price elasticities between beef and pork and pork and beef, respectively.

W_p and W_b are the budget proportions spent on pork and beef, respectively.

E_p and E_b are the income elasticities of pork and beef, respectively.

[3] This is true. However, models of the type they estimate show the net effect of these factors. Hence goods will be either net substitutes or net complements; they will not be both simultaneously unless we are at point A, Figure 1.

[4] Since price flexibility is the reciprocal of elasticity, relationships concerning the sign of the elasticity will also hold for flexibilities.

When the budget share (W_p) is small the last term in the above equation is close to zero. Thus, we normally expect E_{bp} to approximately equal $(W_p/W_b) \cdot E_{pb}$ [4, pp. 83–84]. Their results state that $E_{bp}<0$ and $E_{pb}>0$. This can occur only if $E_{pb}<W_b\ (E_b-E_p)$. That is, the income elasticity of beef must be so large that $E_b>1/W_b\ (E_{pb}+E_p)$. Given that W_b is less than .05, this means that the income elasticity would have to be more than 20 times as large as the sum of E_{pb} and E_p. No empirical evidence will support this. Moreover, this conclusion does not conform to their contention that the consumer is tired of beef.

I suggest that the positive beef-on-pork flexibility they obtained in equation (2a) is a result of statistical problems and does not stem from the fact that beef is complementary to pork while at the same time pork is a substitute for beef. Problems of multicollinearity and serial correlation in the data apparently have made it impossible to identify the correct structural coefficients. Specifically, they may have introduced statistical problems by dividing slaughter data by their index of workdays. The use of ratios as independent variables in regression analysis can lead to biased regression coefficients, especially in time series data [2]. It is not clear that adjustments of slaughter days is necessary. Varying length of months and holidays are well-known to buyers and sellers and are a constraint on both sides of the market. Prices are determined by the same number of days of market operation as are slaughter numbers. Thus prices already reflect adjustments for the number of work days a month.

If it is thought to be important, the workday index could be used as an additional independent variable to see whether it has a significant effect. I doubt that it has. Most holidays occur in the same month each year; and since the length of each month is fixed, the number of slaughter days for a given month would not exhibit much year-to-year fluctuation. The monthly dummy variables probably would pick up most of this effect.

The structure of their model appears quite reasonable. However, statistical problems apparently preclude accurate measurement of the specified parameters.

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MONTHLY SUPPLY-DEMAND RELATIONSHIPS FOR FED CATTLE AND HOGS: A REPLY AND SOME EXTENSIONS

Dr. Bullock rejects the estimated parameters in our model [2] because we found divergent signs on the beef and pork cross-price flexibilities. He also does not accept our conclusions concerning beef-pork complementarity, as he interpreted them. To be precise, let us restate the conclusions actually stated in our previous paper: "The sign of this [the hog price-beef quantity] relationship is positive, suggesting that hog prices go up as cattle supplies increase. This result seems inconsistent with normally expected market behavior and the (negative) cross-flexibility in the beef demand equation. Beef and pork have been considered competitors (though not perfect) for the consumer food dollar. This statistical result certainly could be spurious, possibly because of a model specification or a measurement error, or there may be a plausible explanation" [2, p. 539]. Then, after considering a possible plausible explanation, we state in our summary: "Consequently, any firm conclusions about the degree of competition or complementarity of beef and pork (as reflected at the live market level) could not be reached" [2, p. 543].

Let us examine Bullock's argument in more detail. He begins by observing that the marginal utility of additional beef consumption is zero. We don't see how he can reasonably make this statement nor how he concludes that the corresponding indifference curve in his Figure 1 is the appropriate representation of the consumer situation.

If the quantity of beef increased, the price of beef typically would go down. This can be represented on typically shaped indifference curves similar to those shown in our Figure 1, where a beef price decrease ($P_{B_1} \rightarrow P_{B_2}$) results in increased consumption of both beef and pork. A pork price decrease ($P_{P_1} \rightarrow P_{P_2}$) results in increased pork consumption and reduced beef consumption. Note that both the own-price flexibility (or elasticity) and the cross-price flexibility (or elasticity) are both operative simultaneously with a change in the product quantity (or price); i.e., a beef price decrease in the above illustrations causes both increased beef consumption and increased pork consumption. This appears consistent with our estimated parameters and appears inconsistent with Bullock's assertion that our findings imply that the marginal utility of beef (and its price) would be zero. With a change in the quantity supplied and a corresponding price change, the consumer shifts to a different indifference curve rather than moving along the same curve as depicted by Bullock. Similarly, a change in the price of pork causes the consumer to shift to yet another indifference curve. Consequently, any precise deduction about the necessary shape of the indifference curve and the corresponding marginal utility of beef seems fraught with peril. Thus, Bullock's assertion that our argument implies a zero marginal utility for beef is very likely incorrect. His subsequent deduction that the "price of beef would be zero" is based upon his indifference curve assertion and is subject to the same limitations. His observation that the price of beef is positive is consistent with our statistical results; and the positive sign of the income coefficient implies that beef prices have had a tendency to increase as incomes have increased.

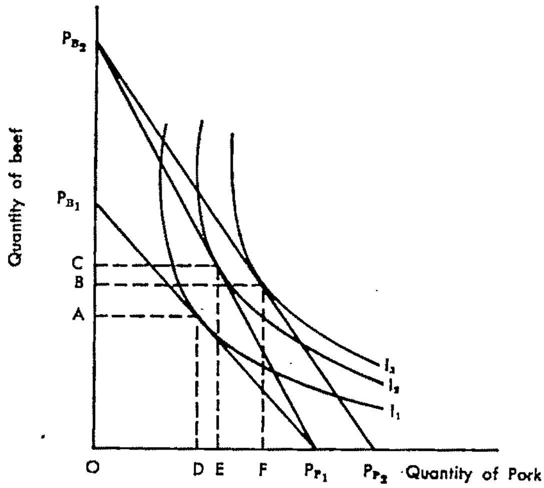

Figure 1

Bullock rejects a possible explanation related to Lancaster's approach to consumer theory because "beef and pork are not consumed in the same meal as a general rule." Under this narrow view of consumption behavior, the Lancaster argument would not apply. However, a closer look at consumer behavior suggests that housewives neither make separate shopping excursions for each meal nor plan the meat component for each meal without considering the recent menu history and planned menus for the near future. Finicky husbands and children have a tendency to recall recent meals, causing housewives to consider them in planning menu sequences that are not too repetitive in taste or texture. By broadening the perception of consumption activities to include several meals on several days (which appears to be the housewife's relevant decision time unit), Lancaster's model does apply.

Bullock then argues that the statistical results are unacceptable because he observes divergent signs on the price cross-flexibilities, rather than agreeing with our thought that the possible complementarity of beef and pork should be considered as an hypothesis that needs further examination and testing. He bases his reasoning upon the relationships that would have to hold true as derived from the Slutsky equation. Two points seem relevant in considering this judgment. First, as shown by Houck [3], the transformation of flexibilities into elasticities isn't quite as easy

as simply taking the reciprocal of the flexibility. However, the signs of the cross-elasticities do remain divergent.[1] Second, our analysis was concerned with *aggregate* market demand relationships rather than *individual* relationships. Wold and Jureen argue that the Slutsky relation, while true for an individual, "has no direct analogue for market demand" [5, p. 120]. Thus, there is no theoretical basis for expecting that the Slutsky equation relationships should hold true in the aggregate market behavior being analyzed. Consequently, Bullock's rejection of the statistical aggregate market behavior parameter estimates because two estimated parameters were inconsistent with the Slutsky equation (which applies only to individuals) appears subject to question.

Bullock then suggests that the results were awry because of statistical problems due to our specifying the slaughter per workday as the quantity variable in the model. He cites Kuh and Meyer's analysis of the statistical consequences (biased estimates due to spurious correlation) of inappropriately specifying a variable as a ratio (say, a deflated price) when the relationship between other variables and the numerator of the ratio (the price) is the relationship of interest. However, he fails to mention, as do Kuh and Meyer, that "the question of spurious correlation quite obviously does not arise when the hypothesis to be tested has initially been formulated in terms of ratios" [4, p. 401]. Specifying slaughter per workday as the quantity variable seems appropriate since this variable is analogous to the daily market receipts that many market participants consider in their daily price decision-making throughout the month. Since one is analyzing the behavior of the average of prices paid on market days during the month, it seems appropriate to relate this to our best index of the average quantity sold per day rather than the total quantity sold during the month. Bullock has indicated that our argument for this kind of adjustment is not convincing, suggesting that varying lengths of months and holidays are well-known to buyers and sellers. In like manner they are well-known to price analysts, but the statistical quantity series are not adjusted to let the analyst know whether that quantity was aggregated from sales on 19, 20, 21, or 22 market days or workdays. Consequently, the use of the total quantity can be quite misleading when one is concerned with analyzing short-run behavioral relationships. While monthly dummy variables would typically pick up most variations in the number of days in a month and the incidence of holidays in a month, they do not distinguish between a January with 10 weekend days in 1971 and a January with 8 weekend days in another year. This type of discrepancy between quantity indices can be alleviated by using an adjustment such as workdays.

As we suggested in our article, the possible beef-pork complementarity was a hypothesis that needed further examination. To delve into this and other interesting facets of beef and pork price behavior in more detail, a 20-equation model of the U.S. wholesale beef and pork supply, demand, and storage behavior has recently been specified and estimated [1]. The demand for each wholesale primal cut of beef and pork was specified individually within this model in a relationship quite analogous to the cattle and hog demand equations in the model previously discussed.

The estimated coefficients for selected beef and pork wholesale cuts also suggested possible complementarity between beef and pork.[2] Wholesale beef cut prices did not appear to be significantly related to pork quantity changes, with one positive and three negative cross-flexibilities all near zero. A large positive cross-flexibility between pork belly prices and beef quantity was estimated, suggesting that the demand for the products derived from pork bellies was increased when beef supplies increased. A similar but weaker relationship was noted between ham prices and beef quantity.

While the estimated wholesale cut demand relationships may also be spurious, they may add some further insight into the possible complementarity between beef and pork. The two cuts (ham and pork bellies) exhibiting the unexpected sign of the cross-flexibility are those wholesale pork cuts which typically undergo the most processing before reaching the consumer. The resulting taste, textural, and other psychological consequences of smoking, curing, adding moisture, or differentiated packaging may make these cuts appear to be markedly different from most beef cuts in taste and texture. Thus, they may be the logical consumer choice for additional consumption of pork if there is a demand for maintaining variety within the meat menu structure when beef supplies increase and prices drop.

How significant are these unexpected positive price cross-flexibilities? The statistical evidence is still weak. If this complementarity should be proven, beef producers and processors may want to consider various ways of developing more taste and textural variety within beef cuts. By doing so they may be able to alleviate any possible satiation of consumers' demands for the current mix of product characteristics, and the demand for beef products may be expanded more rapidly in the future. More complete analysis of consumer meat-purchasing behavior at the retail level will be necessary to determine whether (1) consumer demand for some meat product characteristics is becoming satiated, (2) the desired mix

[1] The resulting approximate elasticities (calculated at the means) are $E_{bb} = -.84$, $E_{bp} = .14$, $E_{pb} = -.35$, $E_{pp} = -.59$, where E_{bb} and E_{pp} are the own-price elasticities for beef and pork, respectively, and E_{bp} and E_{pb} are the price cross-elasticities.

[2] This discussion is summarized from chapter 3 of Hacklander's recently completed unpublished Ph.D. dissertation [1].

of product characteristics is limiting the demand for beef, or (3) some further fabrication and processing would alleviate any observed limitations on per capita demand for beef (or pork).

In summary, we reject Bullock's contention that our analysis implies a zero marginal utility and price for beef, as we have demonstrated that our estimated coefficients are consistent with typically shaped consumer indifference curves. His rejection of all our estimated relationships because two coefficients are inconsistent with the Slutsky equation seems unreasonably harsh, since the Slutsky equation (which explains individual consumer behavior) is not valid for market demand relationships. (It is one of exceptions; most other theorems related to individual demand elasticities are valid for market demand [5, p. 120].) Our specification of the quantity variable as a quantity per workday appears reasonable from a behavioral standpoint; consequently, the spurious correlation problem cited by Bullock does not appear relevant to our situation. Finally, we have considered some additional evidence about beef and pork complementarity to which Bullock did not have access. We conclude that, while not perfect, our cattle and hog supply and demand behavior analysis and results have some usefulness; and the possible complementarity between beef and pork, while unproven, remains a plausible hypothesis that needs testing.

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COST-SHARE LEASES REVISITED . . . AGAIN

Among the perennials of economic literature, surely some type of award is due the "share-lease paradox" —both for its longevity and its fecundity as a source of journal articles (this one included, of course). The "problem" consists of a demonstration that an output-share lease leads to an inefficient combination of firm's resources unless variable costs are also shared in the same proportion. The "paradox" arises from the continued world-wide popularity of output-share leases *without* the cost-share feature.

The origin of the problem is generally attributed to Adam Smith [16]; the diagrammatic exposition to Alfred Marshall [12]. More contemporary treatments are available from Schickele [14], Heady [8], Issawi [10], Georgescu-Roegen [6], and others. The problem has led to ambitious but generally unsuccessful research projects designed to empirically validate what theory says should exist [9, 13]. And it has led others to accept the economic logic in principle while at the same time denying its empirical validity [3, 11].

The problem was recently resurrected by Adams and Rask in an article in this Journal [1]. It has since elicited communications by Gisser [7] and by Scott [15]. All parties to this current exchange have at one point or the other touched on basic inconsistencies of the traditional presentation of the problem, but all have failed to directly challenge it. Meanwhile, and independently, Cheung has correctly identified the fallacy of the traditional model [4, 5].

The purpose of this note is to present a model of share-tenancy that is consistent with the assumptions of perfect competition in the leasing market. We do not comment on the specifics of lease practices in less-developed countries as discussed by Adams and Rask or by the previous communications except to make the point that leasing inefficiencies must arise from market imperfections rather than from some unique features of output-share leases.

We have reproduced Adams and Rask's model here (Figure 1). They assume a traditional 50–50 output-share lease without cost sharing. Line AQ_3 represents the marginal value product (MVP) to the firm for variable factor X_1, holding land and all other factors constant. Line BC represents the firm's marginal factor cost (MFC) for the variable input. An owner-operator would produce at the Q_2 level of input where firm MFC equals firm MVP.

A tenant under a 50–50 output-share lease would perceive line DQ_3 to be his MVP schedule (i.e., one-half of the firm's MVP). If the landlord pays none of the costs of the variable input, the tenant has incentive to produce only to the Q_1 level, the point at which the firm's MVP is twice the firm's MFC. This allocation is of course inefficient from a firm viewpoint. However, if the landlord agrees to share the cost of the variable input in the same proportion as he shares in the output (the "ideal lease") the tenant's MFC schedule becomes HM. He will now have incentive to add inputs to the level Q_2, maximizing the firm's profit with respect to X_1 and in-

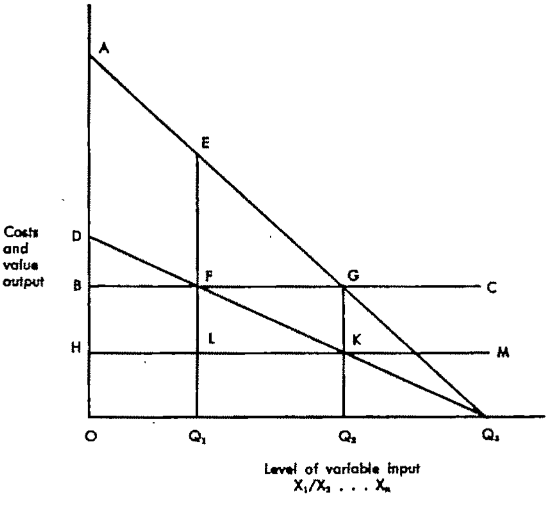

Figure 1

creasing net return to the firm from $BAEF$ to BAG.

The tenant will adopt the ideal lease, it is alleged, because his "economic rent" increases from BDF under the traditional lease to HDK.[1] But wherein is the incentive to the landlord under this arrangement? Previously, his contribution to the cost of the variable factor was zero but he received the rent represented by area $DAEF$. Now he must bear one-half the cost of all of the factor X_1 (area $BGKH$) in return for the additional rent equal to area $FEGK$. Adams and Rask deduce that the landlord would be willing to adopt the ideal lease only if the latter area exceeds the former but then conclude that empirical evidence would be necessary to establish the numerical importance of landowners who would realize less net returns by adopting ideal leases.

Gisser's communication was directed primarily at the "cumbersome geometrical analysis" of Adams and Rask's presentation. He provides a mathematical treatment based on a Cobb-Douglas production function. From this function he concludes that under an ideal lease with 50–50 shares the landowner gives up one-half the MVP of *land* to the tenant. Unfortunately, the inconsistency of this conclusion with Gisser's explicit assumptions of perfect competition and a criterion of payment to resources according to their value of marginal physical product is overlooked.

The first point that should be noted is that the nature of the variable factor X_1 is generally not specified in the model. To judge, however, from model crop-share leases based on the analysis [17], X_1 is understood to represent some nondurable purchased asset (seed, fertilizer, gasoline, etc.). Curiously enough, the model nowhere treats the tenant's labor itself—unless the previously identified "economic rent" attributed to the tenant is taken as a reimbursement to labor.[2] Then labor earnings are either the sum of this rent component for each variable factor used in the firm's production process, or labor returns are somehow determined independently of the model. Neither explanation contributes very much to analytical rigor.

Following Cheung, however, we can utilize Adams and Rask's model by assuming that labor is the only variable factor. To make this explicit, we relabel the abscissa as "tenant labor per unit of land" and the ordinate as "product per unit of labor." The line AQ_3 becomes the MVP of labor to the firm which, consistent with the assumption of perfect competition, we assume is defined by either prevailing wage rates or the tenant's opportunity earnings under a cash lease. If the landowner hires farmhands to do the tilling, equilibrium is at Q_2 and the total rent received by the landowner is represented by the area BAG. This also amounts to what could be received from a cash-rent lease.

Point Q_2 is the equilibrium level of labor input for an owner-operator supplying his own labor, for an owner-operator hiring the labor input, or for a landlord leasing to a tenant under a cash lease. It follows, therefore, that to obtain the same equilibrium solution for a crop-share lease it is necessary only that we locate line DQ_3 so that area $DAGK$ is equivalent to area $OBGQ_2$ *and* area $ODKQ_2$ is equivalent to area BAG. The partitioning of total returns by line DQ_3, in other words, is only an alternative way of illustrating the allocation of factor returns in equilibrium—an allocation already illustrated by the firm MVP and MFC curves.

Abstracting from risk-sharing features, the essence of a crop-share lease is seen to be payment in kind in lieu of wages or cash rent. If we assume zero transaction costs and mobility for both tenant and landlord, the *general* equilibrium solution requires output to be produced and shared in such a way that both tenant and landlord are paid their opportunity returns.

The model in Figure 1 does not necessarily illustrate the equilibrium solution, however, for it may not be possible for landlord and tenant to allocate relative shares in such a way as to simultaneously optimize firm output and pay both parties their opportunity returns (since the only "instrument" is negotiation over the share rates determining the location of line DQ_3). A complete treatment of the

[1] We follow Adams and Rask in qualifying the term "economic rent" [1, p. 937]. The source of their trouble is understandable since, from the context of the presentation, land is the fixed factor in the model and hence the landlord is the logical claimant. As Cheung asks, what is the incentive for the landlord to give up even this rent under the traditional lease?

[2] In Adams and Rask's reply to Scott, however, they state, ". . . in many cases share-renters in LDC's apply, aside from labor which is usually not cost-shared, economically insignificant amounts of variable inputs" [2], which seems to eliminate not only labor but the problem itself from economic consideration.

model must therefore recognize the other conditions of the lease contract that are subject to negotiation. Cheung's presentation makes this clear (Figure 2).

Cheung begins by assuming a vertical supply curve, S indicating the total area of land belonging to a landlord. Line AB is again the MVP of labor on the given unit of land. Cheung labels line CD the "marginal contract rent" curve, which seems a preferred terminological alternative. It is located, as before, according to the output share-ratio agreed to by the two parties. The tenant receives the return equivalent to area $ABDC$ as his labor earnings and the landlord receives rent equal to area CDQ_10.

If either party earns less than his opportunity return, an incentive to renegotiate the share-rate exists. But each party also has an incentive to attempt to increase his earnings by other means—the tenant by restricting his labor input; the landlord by restricting the amount of land he makes available to the tenant (shifting schedule S). Thus the landlord will not allow one tenant to cultivate all the land he owns if parceling his lands to several tenants will result in a higher total rent. Similarly, the tenant will not lease from only one landlord if by parceling his labor over the lands of more than one landlord he can increase his total earnings. In order to reach a mutually agreeable contract, then, the landlord and tenant must agree to three conditions: (1) the share rate; (2) the amount of land the landlord is to contribute; and (3) the amount of labor the tenant is to supply. (See [5] for full discussion and mathematical proof.)

No further model modification is required to treat the other variable factors which the tenant is usually expected to provide. The fallacy in the traditional presentation of the model is the assumption that the tenant need consider only *his* interests in deciding how much of the variable inputs other than labor he is to supply. But, again, this implies a resource fixity explicitly ruled out by the assumption of perfect competition. Under competition the tenant must meet two conditions: (1) maximization of personal returns to labor (and management); and (2) maximization of rental returns to the landlord to insure retention of the lease. Together these conditions assure maximization of firm returns. Cost sharing may be adopted in lieu of adjustment in output shares, but it is not required for economic efficiency. All that is required is a competitive market in which both landlord and tenant have economic alternatives (but this is all that is required for leasing efficiency in general).

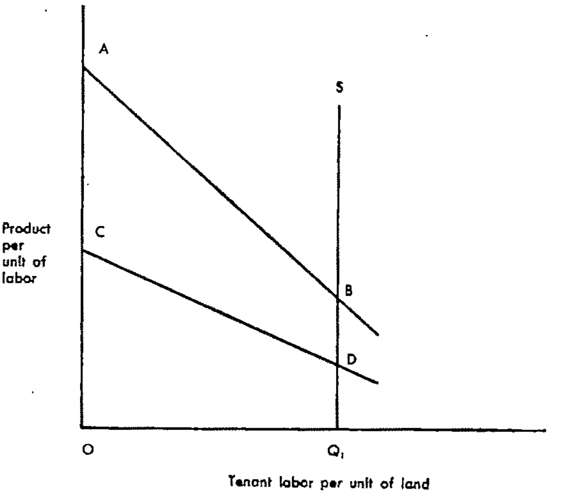

Figure 2

It is interesting that writers on sharecropping never committed the same fallacy, perhaps because both the payment-in-kind feature and the considerable discretion of the landlord in apportioning his land among tenants were recognized. A special set of institutions surround share-cropping in the United States, but from a theoretical viewpoint there is no reason to treat it differently from other output-share leasing.

One may readily object that we have no grounds for assuming that the leasing market is any more perfect than most other markets. This may well be true but, if so, we should direct our attention to the market as the source of leasing inefficiencies. There is, however, no assurance that cost-shares in proportion to output-shares is the panacea for these problems.

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FLOW-OF-FUNDS SOCIAL ACCOUNTS FOR THE FARM SECTOR: A CORRECTION

The Journal, in publishing our recent article [1], failed to make two corrections we requested on the galley proofs (corrections 1 and 2 below). In addition, several terms had been inadvertently omitted from equation (1.2) in a late draft of the manuscript and need to be reinstated (correction 3 below).

1. Equation (2.3) should have read as follows:

$$PW = \sum_{i=1}^{M} (CC_i + NFY_i + OFY_i + \Delta RED_i + \Delta NRED_i + CA_i) - \sum_{i=1}^{M} (NCE_i + \Delta I_i + IRE_i + \Delta FA_i)$$

Previously, equation (2.3) implied a double accounting of real estate capital expenditures, appearing in both CE_i and IRE_i, and did not follow from equation (2.2) minus equation (2.1).

2. Line 7 of Table 2 should have read "Total non-real estate capital expenditures 4.8." Otherwise, uses of funds listed in Table 2 will not sum to the published subtotal of $17.5 billion.

3. Equation (1.2) should have read as follows:

$$SF = \sum_{i=1}^{N} (CC_i + RCE_i + \Delta CMI_i + \Delta TD_i + NFY_i - PYW_i) + PNI$$

Only then does equation (1.3) follow from equation (1.1) minus equation (1.2).

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EMPLOYMENT OF AGRICULTURAL ECONOMISTS

At the close of 1970 I asked the departments of U.S. universities that grant doctorates in agricultural economics for the following information on employment of their Ph.D. recipients: (a) for those who received their degrees in 1960, the individual's first job and his job in 1970; (b) for those who received their degrees in 1970, the beginning job. Twenty-six departments responded, accounting for 91 doctoral degrees conferred upon U.S. and Canadian citizens in 1960 and 170 in 1970. This is close to all doctorates in agricultural economics received by U.S. and Canadian nationals in these two years. (Other recipients are not included in this analysis for the sake of homogeneity as well as avoiding attenuation of the basic argument.)

The matter at issue is whether our employment is becoming less centered around academic institutions and the reproduction of doctorates. For two decades, the Journal's May issues have been reporting the acceleration in doctorates—those for 1960 were approximately double 1950 and from 1960 to 1970 the number doubled again. And it would be difficult not to be aware that a very large proportion of this output has been employed to expand preexisting graduate departments and to create new ones, thereby to produce still more doctorates. Dale Hathaway commented on the market implications of these trends at the 1969 Annual Meeting [5]. In November 1969, Emanuel Melichar provided our readers with evidence from the *National Register* on the employment of scientists in 1966, from which I drew the inference that agricultural economists (presumably an applied subsector) were incredibly institution-bound. Melichar's report was that "educational institutions employed 58 percent of agricultural economists, as against 45 percent of economists generally and 36 percent of all scientists . . . Only 9 percent were employed by business and industry, compared with a third of all economists and 41 percent of all scientists" [6, p. 904].

Is the employment base for professional agricultural economists becoming more diversified? The

reports summarized herein suggest that academic inbreeding was still dominant in 1970 although a modest tendency toward diversification may have commenced.

As is reflected in Table 1, doctoral degree recipients of 1960 concentrated in teaching and research to the extent of 70 percent in their first employment and were at the same level of concentration ten years later. Of 91 degree recipients in 1960, 64 went directly into academic employment and 49 of the 64 were still in this employment (but not all at their initial institution) in 1970. As Table 2 reports, there was some shifting about of 1960 degree recipients between 1960 and 1970; departures from and entries into teaching and research were approximately offsetting.

The first-job profile for 1970 degree recipients differs somewhat from that for 1960 recipients: USDA, other U.S. government, and private industry are gaining as against teaching and research. However, when U.S. academic and USDA employment (including state and federal extension) are aggregated, the proportion remains at four-fifths. Other government employments for 1970 include TVA, Federal Reserve, Federal Housing, and state and city planning agencies. These areas of government, along with the modest but steady increases in private industry (including cooperatives) may well be the employment categories of potential growth.

Does it matter that 94 doctoral recipients in 1970 were employed in teaching and research as against 64 recipients in 1960, even though the percentage declined from 70 to 55? It very well may. And if the 94 new appointees together with their previously and subsequently appointed colleagues are to be engaged principally in production of new doctoral candidates trained primarily for academic appointments, it could matter a great deal. There are too many signals of academic surfeit to believe otherwise. They come from our own subdiscipline and from others.

According to the Colyer-Torgerson report on the AAEA employment service [4], 70 percent of all applicants still aspire to teaching-research appointments. In total some 180 applicants in 1970 wanted

Table 1. Employment in 1960 and 1970 by U.S. and Canadian recipients of doctoral degrees in agricultural economics conferred by U.S. universities in 1960 and 1970

Classification of employment	1960 recipients: Job in 1960	1960 recipients: Job in 1970	1970 recipients: Job in 1970
U.S. universities/colleges (teaching and research)	64	59	94
U.S. Dept. of Agriculture (excl. Extension)	10	8	31
Agricultural Extension (state and federal)	4	1	8
Foreign universities/colleges	0	2	7
Government, other than USDA, in United States	4	0	14
Foreign government	3	1	3
Private industry	4	7	11
Foundations or institutes	2	3	2
University administration	0	3	0
Totals	91	84[a]	170
Percentages:			
U.S. universities	70	70	55
USDA (excl. Extension)	11	10	18
All U.S. academic, USDA, and Extension	86	82	80

[a] Total less deceased or unknown.

academic positions, but only 67 academic vacancies were listed. Only 50 job vacancies were listed by nonacademic employers, and they were principally in government. Total job vacancies listed with the AAEA employment service declined from 217 in 1966 to 117 in 1970.

Of the 26 departments included in the present survey, the 1970 doctoral outputs of 12 went exclusively into the academic-extension-USDA complex. Ten departments produced the 14 appointments in "other government"; 7 departments produced the 11 appointees in private industry, but 4 of these came from a single department. In this context, one notes also that the Colyer-Torgerson report does not indicate a brisk interest by nonacademic employers at the AAEA employment service, even though proportionally the nonacademic segment of demand exceeds the predisposition of applicants to work in other than academic establishments.

Table 2. Employment in 1960 and 1970 by U.S. and Canadian recipients of doctoral degrees in agricultural economics conferred by U.S. universities in 1960

Employment in 1960		Employment in 1970: U.S. Universities	USDA	Agricultural Extension	Private industry	Other U.S. government	Foreign government	oundations or institutes	Foreign universities	Academic administration	Deceased or unknown
U.S. universities/colleges (teaching and research)	64	49		1	4			2	2	2	4
U.S. Dept. of Agriculture (excl. Extension)	10	2	7		1						
Agricultural Extension (state and federal)	4	3								1	
Private industry	4	1	1		1						1
Government, other than USDA, in United States		3									1
Foreign government	3	1			1	1	1				1
Foundations or institutes	2							1			
Totals	91	59	8	1	7	0	1	3	2	3	7

Prominent among the individuals who have been concerned about labor markets for academic professionals is Chancellor Allan M. Cartter of New York University, whose perception is that:

> For a decade colleges and universities each year have employed 50 percent or more of the new Ph.D.s. At the conclusion of 1970, the figure may be 35–40 percent. It will probably never exceed 40 percent again and, by the end of this decade, only a quarter or less of the new doctorates will enter college teaching. We are experiencing one of the most radical changes in the condition of higher education which has ever occurred, and it will have a major impact on the whole academic world.
>
> Such a dramatic change should also give us pause to reflect upon how little we know about ourselves, how little thought we have given to the development of our educational system, and how inaccurately we have cast our objectives and done our planning. No great powers of intuition or prophecy were required to see that the academic environment was about to change dramatically; all one really had to do was look at the evidence and not put the blind eye to the telescope [2, p. 334].

In a recent issue of *Science*, Chancellor Cartter says further:

> The price of a surplus of Ph.D.'s (surplus in terms of traditional jobs) is not unemployment, but rising under-employment. Associated with it frequently are personal disappointments, and a gradual erosion of hard-earned skills and intellectual agility. There is a social cost (about $50,000 is directly invested in the individual with the Ph.D., plus an equivalent amount invested in others who began, but did not complete, the degree), but the human cost in unfulfilled expectations and discouragement may be even more important [3, p. 138].

It needs to be noted that the above quotations are in reference principally to doctorates in chemistry, physics, biology, and mathematics, none of whom are as institution-bound nor have as narrow an employment base as do agricultural economists.

There probably is no segment of society more preoccupied with excess capacity, product surplus, and market disequilibrium than agricultural economists. Yet we apparently have not had the prescience to direct this consciousness to our own market situation. In this respect we apparently share impassiveness with other disciplinary participants in science labor markets.

Are we facing labor market disequilibrium of significant if not tragic magnitudes?

I don't believe that either the question or the evidence should be shrugged off, as in my view were the comments of Buchanan and Hathaway at the 1969 Annual Meeting. We (and by "we" I mean all of us but especially the administrators of graduate programs and the AAEA itself) apparently face several possibilities, and the following are prominent among them: (1) Go along without any reevaluation or redirection and let the costs fall as they may, including the prospect of having to struggle through some accommodation to excess capacity in presently existing graduate departments; (2) cut back on graduate admissions as Harvard and Yale are doing and thereby avoid some of the costs mentioned by Cartter in the above quotation; (3) undertake a more vigorous (i.e., forsake the past impassive) program of nonacademic job development, thereby to buttress and diversify our employment.

These possibilities are not alternatives and they all are likely to occur in some combination. Whatever that combination, it is manageable; and I believe the elders of the profession owe the fraternity more responsibility than heretofore assumed, especially with respect to new job development. Where would medicine, architecture, and engineering be today if no more than 20–30 percent of their professionally trained personnel had ventured outside the halls of academia? Our situation may be dissimilar in some respects, but not that much. Even without making changes in graduate curricula our people have more versatility than has yet been exploited in their utilization. And along with nonacademic employment promotion, appropriate changes in curriculum need not be excluded.

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P.S. The departments reported no unemployment of 1970 doctorates, but some possibilities of under-employment did appear.

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Reviews are listed alphabetically by authors.

Reviews

Barkin, David, and Timothy King, *Regional Economic Development, The River Basin Approach in Mexico*, Cambridge, Cambridge University Press, 1970, x + 262 pp. ($10.50)

This book attempts to wed two Ph.D. dissertations and some six years of research on Mexico into an assessment of Mexican regional development. Its primary concern is with river basin projects, as Mexico's strategies of regional development have included no other kinds for all practical purposes. Analysis focuses on the Tepalcatepec River Basin in particular, the smallest (in terms of investment outlays) of four developed by the Mexican Government since 1947 at a total cost of about US $300 million. The purpose of such investment is to integrate development of regional resources. The nation has been criticized, but sometimes admired, for its unintegrated policies of development for most sectors of the economy.

The first four chapters, primarily King's contribution, offer a somewhat breezy but informative discussion of regional development policies. In the opening chapter we are told that regional development will differ in degree or kind from the process of national development in the role interregional (versus international) trade will play, in the questions of how growth in one region affects growth elsewhere in the economy, and in the mechanisms by which interregional payments may be balanced. The following three chapters discuss regional development in the Mexican context. In the absence of necessary data, the conclusion is inferred that interregional linkages, forged by flows of products and factors (except perhaps labor), have been slight in Mexico as "inter-regional disparities in levels of income and rates of progress are very marked . . . and have caused a good deal of concern."

The following three chapters, coming principally from Barkin's study, examine the Tepalcatepec River Basin Project, begun in 1947. Quickly the discussion centers on the Tierra Caliente region, as the major share of expenditures were made in irrigation facilities in that part of the Basin. Cultivated land increased 160 percent, irrigated land jumped 480 percent, and gross monetary yields per hectare about doubled between 1950 and 1965. Two thirds of the yield increase is attributed to a shift in cropping patterns induced by irrigation—from maize, rice, and sesame to cotton, melons, and watermelons. Physical yields increased only about 5 percent.

Comparing changes in net value of farm output (gross output less "production costs") in Tierra Caliente with what occurred in Ciudad Altamirano, a region in neighboring Guerrero State not benefited by irrigation developments during the period, (lower-bound estimates of) internal rates of return of between 10 and 13 percent are estimated for the Tepalcatepec project. This "marginal success," in economic terms, is attributed to a long time lag between completion of the irrigation facilities and growth in agricultural output. Social returns from related, nonagricultural investments (primarily in hydroelectric power facilities) appear to have been low also.

The last chapter attempts to tie together the first section of the book with the benefit-cost analysis of the second. The political, as opposed to the economic, rationale of undertaking the Tepalcatepec project is underscored, as well as reputed effects of the project on absorption of unemployed or underemployed inputs, decentralization of economic activity, and mobilization of local savings and investment. On net, however, the authors do not become enthusiastic about river basin projects on the basis of the Mexican experience:

> . . . a more positive strategy than river basin schemes is needed to achieve the development of lagging regions. Social overhead capital is only a permissive policy which will not necessarily bring development in its wake.

This last wrap-up section fails to really wed the

two studies. The book overall reads as it was written—as two studies written by two people. My own preferences would have been more adequately satisfied had early sections of the book been substituted with more thorough discussions of the evaluation of the economic and other benefits of the Tepalcatepec project, since I find unconvincing and incomplete the conclusion that the project barely paid for itself. Much faith must be exercised in accepting estimates of the "net value" of agricultural production in Tierra Caliente. Little explanation is given for the particular choice of data, although immense differences in acreage and yield estimates are evidenced in the Mexican sources available. "Production costs," subtracted from gross output to obtain the "net value" figures so critical to calculations of internal rates of return, are said to have been estimated in a field investigation (how "representative" or adequate, we are not told) and are defined in a footnote of seven lines (page 160). Also, almost no discussion of the suitability of Ciudad Altamirano as a "control region" is provided, unless one has more faith than this reader in the suggestion by one Ing. Cesar Buenrostro that it be used for that purpose (footnote, page 212).

These are not minor matters. In a country in which data is a congenital weakness—something to be overcome—readers should be apprised of how data problems were overcome. Further, some indication of the sensitivity of rates of return calculations to alternative data should be provided.

Finally, there are several methodological qualms a reader might have with the work. For example, why were benefits of the Tepalcatepec Project calculated in the (rather difficult) way they were? We are told in a footnote (page 214) that

> . . . this method for measuring benefits from irrigation attributed all of the increase in the productivity to a single factor of production—water. In effect, it is an estimate of the Ricardian rent attributed to this one factor after all other inputs into the production process have been paid their competitive price.

Why then is there no reference made anywhere in the book to what happened to the prices of agricultural land?

In short, the book covers much important material but suffers from an unsatisfactory wedding of two studies and insufficient attention to data and associated methodological problems.

REED HERTFORD
The Ford Foundation

Boserup, Ester, *Woman's Role in Economic Development*, London, George Allen and Unwin, 1970, 283 pp. ($9.95). (Published in the United States by Dufour Editions, Chester Springs, Pa.)

Economic and social development is generally disruptive. Its impact on the economic role and status of women in the developing countries is the subject of this interesting and original study.

Marriage systems, employment, training, and education of women in the rural and urban economies of Latin America, Africa, and Asia are examined. The data is drawn from censuses, special surveys, and reports, and collated for the first time to give an overview of the patterns of female employment and participation. It emerges that modernization and migration to towns entail a disintegration of the traditional division of labor between the sexes. "A new sex pattern of productive work must emerge, for better or worse." Generally, it is for the worse. Woman is looked upon mainly as a residuary source of supplemental, and the less desirable and less remunerative types of work and responsibility.

Contrary to the conventional notion that it is always the male's natural prerogative to provide food for the family, work allocations vary greatly in preindustrial societies. In black Africa where shifting cultivation is practiced, for example, female farming is the dominant pattern. Except for felling of trees, practically all cultural operations for growing food crops are performed by the women of the household. With the introduction of the plough, permanent fields, and European concepts of land ownership, however, the roles are reversed. Women become less active and often do no field work at all.

Marriage arrangements and status of women vary with farming systems. In the first instance, there is a high incidence of polygamy. Additional wives' contribution to food production and income of the family exceeds the cost of their keep. As a consequence they also enjoy a measure of economic independence, but not equality. For tasks requiring male muscle, for example, often labor is hired while husbands and sons act as supervisors. In the second category, monogamous marriage is the general rule. The wife is mainly or entirely dependent for support on the man but enjoys little freedom of movement or action outside the home.

The plough was the first technical innovation that displaced female labor from the farm, with attendant changes in family and production organization. The trend continues with further modernization and specialization to widen the productivity and prestige gap between the sexes. "It is the men who do the modern things . . . women perform the degrading manual jobs . . . men represent modern farming in the village, women represent the old drudgery" (p. 56).

The pattern is repeated in the modern sectors of trade and industry. Nor do women with university education fare significantly better in the administration and professions. In almost every field specialization favors the male. The trend is reinforced and perpetuated by the nature of education girls generally receive and the implicit acceptance of male preeminence by parents and societies, not excluding the industrial.

The author's main policy suggestion for the future is to suitably train and provide women with equal op-

portunity for gainful employment in the rural areas to ensure that improvement in men's earning capacity in agriculture is not offset by a decline in women's participation. Otherwise, educated girls will migrate to towns or persuade their husbands to do so.

Few, and certainly not a female reviewer, could take exception to the recommendation for improving female education and job opportunities. The author is also right in asserting that "it is not desirable—even if it were possible—for male urban employment to expand so rapidly that it absorbs the whole of the male population increase in rural areas" (p. 200). It does not necessarily follow, however, that "if vacancies in towns were filled by urban women hitherto occupied only with domestic activities in their own home, the result would be to deter male migrants, and the net flow of migration would tend to diminish" (p. 202).

In densely populated countries like India, female labor in the towns does not compete with rural immigrants primarily, but with the urban unemployed males. Moreover, the character of rural migration on which the entire argument rests is changing. Thus it is assumed that rural unemployment is seasonal, and agriculture could absorb much more labor with no decline in income or wages provided more labor intensive methods of cultivation are introduced. Also, villagers go to towns generally in search of additional income only. They are "floating" migrants. They still have their land or job in the peak agricultural seasons to return to in the village.

The author appears to overlook the fact that even if this were the whole truth it represents a temporary phenomenon, almost as of yesterday. It is only a question of time, very brief in several countries, when further modernization involving large-scale mechanization of agricultural operations will totally deprive the migrants of any base in the village even at a subsistence level. The inference that developing countries cannot afford capital-intensive methods of farming, and will not therefore adopt them, is logical. But it is not realistic. They are already doing so. The small cultivator and the landless will soon have no choice but to flock to the towns in search of permanent shelter and livelihood. The nature and dimension of migration will have changed radically.

Moreover, as in the past, with changes in technology of production, traditional family and kinship ties also will disintegrate. With them the last cushion for idleness, seasonal or otherwise, voluntary or involuntary, will have been removed well ahead of the state's ability to provide jobs or dole. In which case, and irrespective of the validity of the author's argument for greater contribution to economic development by the female sex, competition from women in the urban labor market is bound to be resented and discouraged, even in countries with women prime ministers!

KUSUM NAIR
Michigan State University

Crosson, Pierre R., *Agricultural Development and Productivity: Lessons from the Chilean Experience*, Baltimore, The Johns Hopkins Press for Resources for the Future, 1970, xvi + 198 pp. ($7.00)

It is well-known that the demand for farm commodities in Chile grew considerably faster than supply in the 1950's. Crosson attempts to explain the reason for this phenomenon by analyzing a sample (and a subsample) of 210 farms in O'Higgins, one of the most fertile provinces in the country. These data, the results of various other less inclusive studies, and national information seem to corroborate the fact that many agricultural properties fall far short of production potential because farmers fail to adopt adequate nonland inputs even though rates of return from their use are substantially above opportunity costs.

Taking issue with the general Schultzian formulation in this case, Crosson claims that an unfavorable input/output price ratio was not a deterrant to input adoption in this decade. While this relationship moved to the farmers' disadvantage as the sixties approached, as late as 1959 fertilizer was still favorably priced in relation to its rate of return. Crosson does not think that marketing bottlenecks are an adequate explanation for the poor performance of agriculture in Chile in the fifties either. He also quarrels with what he regards as a superficial assertion of the CIDA report (Comité Interamericano de Desarrollo Agrícola, *Chile: Tenencia de la tierra y desarrollo socio-económico del sector agrícola*, Santiago, 1966) that landlords don't adopt enough new inputs because they are less price responsive than their counterparts in developed countries, that they do not save enough, and that they engage in too much luxury consumption.

Crosson does argue, however, that the land tenure system retarded the development of agriculture by denying small-scale farmers and farm workers access to adequate education and other modern inputs. He shows that fertilizer, pesticides, and machinery are generally imported and purchased with credit. During the fifties credit was rationed to those who had the needed collateral. Those who did not have an adequate resource base were considered not credit-worthy. Not being able to obtain credit, they could not purchase inputs. Exacerbating the problem, in the mid-fifties the real value of credit extended to the private sector (including agriculture) declined. A further complicating factor was that because of the country's chronic balance of payments problem in this period these imports were subject to a wide variety of direct and indirect controls.

This book is an important addition to the growing body of knowledge on Chile's agricultural sector. But is the remedy really as simple as more credit and few import controls? For a time after 1959 credit became somewhat more available and import policies became less strict. Crosson points out the real value of bank loans in 1961 to 1965 was 69 percent above

the level in 1956 to 1960. Also, in 1960 farm machinery and spare parts were put in the import category requiring the lowest deposit percentage. If Crosson's analysis were correct, we should be able to document some increase in agricultural production. But statistical series show that total agricultural production declined between 1958 and 1963. Are Crosson's policy prescriptions incorrect or merely insufficient? Or could other conditions have changed so much that while Crosson's remedy would have worked in the fifties it was not applicable in the early sixties? Did, for example, the rates of return on investment become more favorable in other sectors than in agriculture, so that landlords could shift investible funds and write off their agricultural losses? Did this latter condition also prevail in the fifties? And how did the situation in the fifties differ from that of the forties?

I admire Crosson for recognizing that much national data available to him were less than adequate and for highly qualifying his interpretations. His analysis, which leads him to believe that use of more nonland inputs would have been profitable, is very credible. But his policy suggestions are, by his own admission, less well-grounded. He asserts, "The conclusion that the failure to seize on production opportunities revealed by the pattern of resource use was due primarily to foreign trade and credit policies is considerably more tentative than that concerning the existence of the pattern" (p. 145).

Pursuant to the foregoing, some other questions may be worth raising. One wonders, for example, at the representativeness of the O'Higgins sample. Crosson notes this general problem but does not make mention of the fact that farms over 100 hectares in size make up about 42 percent of his sample's farmland area, whereas 1966 data published by the Chilean Census Bureau from the Fourth Agricultural Census show that in the country as a whole about 91 percent of the farmland is in properties over 100 hectares in size, and in O'Higgins the percentage is about 70. Does the fact that farms in the largest category are underrepresented in the sample affect his conclusions?

Another problem for those who are concerned with growing unemployment and underemployment in Latin America is the frequent lumping of "machinery" and "fertilizer" into a "modern input" category without being concerned with the social implications of the use of each. If machinery is priced so that it becomes easier to import and if it substitutes for labor, wouldn't it make more sense to spend foreign exchange for fertilizer rather than for machines and to employ more labor thereby?

The data presented by Crosson seem to indicate that the "most productive farms" in his sample employ more labor *and* machines than "least productive farms." But this does not address the question, "How much might a farm produce if it did not invest so much in machinery and used more fertilizer and labor?" This is a crucial policy question in Chile and in the rest of Latin America. It isn't enough to say that machinery and fertilizer use are associated on the best farms and therefore a policy of easing the import restrictions and the credit policy will allow more of these modern inputs to be imported. Crosson avoids this issue by leaving us with the unsurprising conclusion that labor productivity increases on farms in the 100- to 200-hectare range "due principally to scale economies in the use of machinery. . . ."

I also find the discussion of labor quality to be a little superficial. Crosson relates this variable only to education and sees but a slight increase in schooling of the rural labor force (hence, in labor quality) over the decade. But in Chile isn't labor quality as much a function of the land tenure system under which the worker is employed as it is of his education? A sharecropper (*mediero*) on a large estate may well have more incentive to produce than an *inquilino* (resident farm laborer) and both may have more incentive to produce than a wage laborer. A *mediero* gets a portion of the harvest; an *inquilino* frequently gets (and sells) a portion of the crop raised on the small plot allotted him by the landlord. In contrast, the wage laborer gets the same amount whether he works to capacity or not.

The social scientist who is told on page 1 that ". . . the old analytical tools alone will not suffice, because some the new inputs of major importance respond to factors outside the range of traditional economics" and expected, on reading the book, fresh methodology in institutional analysis will feel shortchanged; the economist who is impressed with production function analyses will admire the way Crosson uses the data available to him and the care with which he qualifies his conclusions. The latter may, however, be somewhat annoyed with Crosson's rather elementary discussion of the use of Cobb-Douglas production functions. On the other hand, because he does explain his methodology carefully the book has good potential for classroom use.

Crosson's major contribution is to challenge with some new ideas the believers in two main schools of conventional wisdom: the group that traces the agricultural production problems of Chile to the perversity of cost/price ratios and the other that feels farm output in Chile cannot keep up with demand because landlords are unresponsive to economic stimuli.

WILLIAM C. THIESENHUSEN
University of Wisconsin

Hirsch, Eva, *Poverty and Plenty on the Turkish Farm, A Study of Income Distribution in Turkish Agriculture*, New York, Middle East Institute of Columbia, 1970, xv + 313 pp. ($6.00)

This book, the first in a *Modern Middle East Series* from the Middle East Institute of Columbia, is based on a previously unpublished Ph.D. disserta-

tion. The author lovingly describes and discusses her data in developing estimates of factor shares and income distributions in Turkish agriculture. These data are taken from secondary sources, in which Turkey is especially rich, and most of them date back to the early 1950's.

The book will be of interest not only to students of Turkey and the Middle East but also as a source of information on a subject that has been previously little treated, partly because of the conceptual difficulties and partly because of the measurement difficulties. Eva Hirsch's courageous attack on the first and her exploitation of a large and varied source of data for the second has enabled her to produce a documented picture of income shares and distribution in Turkish agriculture. The principal conclusion unsurprisingly is that "size of land operation is one of the basic factors creating inequality of incomes from farm operation" (p. 169). This inequality of land holdings is further supported by high values of output per acre on large (commercial) farms which are more specialized than the small (subsistence) farms. This picture is mixed, however, and in areas of less rich resource endowment large (extensive) farms have lower returns per unit area than the small farmer who, producing for home consumption, has no product market problem. It is suggested that the spread of the market economy will therefore diminish the importance of this factor in the inequality of income distribution. The mechanization on large farms is also important in increasing both yields and acreage put under the plow, an effect that is only partly offset by higher costs. On the other hand, income from livestock, nonfarm employment, home processing of farm products and renting-out of land by small farmers tend to decrease the inequality.

In a book dealing essentially with large amounts of data and their manipulation there is a conspicuous absence of any statistics. The author is content to give mean observations from the data—nowhere are there even any ranges or other simple descriptive statistics which would permit the reader to judge the value of the data. Also absent is any hypothesis or test of validity of the conclusions. This weakness is also evident in the lack of any clear theoretical framework. If this had been present, much of the discussion of the numbers could have been eliminated and more attention given to their substance.

It has to be said that this is not an easy book to read. The text is often awkward. There are in the book's 313 pages 137 pages of appendices, footnotes, and references. The practice of putting footnotes and references at the end of the book is infuriating; the continuous flipping backwards and forwards also resulted in disintegration of the book's paper binding. There is not a single map or chart. These could have simplified the exposition enormously. Finally, the title is misleading, although the subtitle is not.

In summary, the book provides detailed estimates of income distribution in Turkey as of the early 1950's. It does not provide much insight into the economic role or process of agricultural income distribution in a low-income country.

MALCOLM J. PURVIS
University of Minnesota

Joravsky, David, *The Lysenko Affair*, Cambridge, Harvard University Press, 1970, xiii + 459 pp. ($13.95)

Why, in a regime that professes to be based on scientific thought as well as realism, were Soviet leaders so quickly moved to support the agrobiologist Lysenko and then so long reluctant to abandon him and other pseudo-scientists who despised the methods of science and feared scientific discussion? David Joravsky traces the "evolving interaction of agriculture, natural science, ideology, and political power" (p. xii) of the four decades spanning the rise and fall of T. D. Lysenko in order to distill some highly satisfying answers. Consequently, his fine book is far more than the history of a feckless charlatan. (That Joravsky has entitled it *The Lysenko Affair* should not put off the prospective reader; for, in view of what he has written, there is no way in which this brief but nicely old-fashioned title—connotative as it is of scandal in high places—could be justly translated into something like *The Lysenko Caper.*)

Joravsky holds that farming, not ideology, was the basic problem underlying the turn to Lysenko. Ideology was involved, of course, in the compulsions driving the Kremlin. The brutal sacrifice of science and agriculture was by a regime whose fear-ridden arrogance long prevented it from understanding either the requirements of science or the costs of the trade-off of an underfinanced, collectivized agriculture for the Kremlin's investment in heavy industry. In the conviction that power creates truth, practice was the guide of thought, for the job of science was to catch up with and illuminate practice. But whether practice or theory, as Joravsky sums it up, there was only one real guide: "The boss knows best" (p. 238). The boss did not, of course, and the theme of the book is that of the inarticulated "underlying issue"—the protracted and bitter conflict between "Stalinist willfulness and scientific realism" (p. 96).

The nuances of Joravsky's account cannot be recaptured here, but he shows that in the long contest of politics with science the Kremlin was never quite fully to prevail and was finally forced to concessions far beyond anything in Stalin's ken. When the issues were joined, agricultural scientists, like others, usually took the course of obscurity or silence but some endorsed or yielded to Lysenkoism. But these "pliable men of scientific principle . . . managed to keep functioning as a scientific community" (p. 201), while the geneticists—a highly visible and theoretic discipline—were overwhelmed with disaster. Joravsky's implicit distinction between scientists and intellectuals permits him, in the main, to cast intellectu-

als in the roles of timeservers and sycophants; the heroes of the account are the "Varangians" (p. 166), a small group of chemists, physicists, and mathematicians "who ventured out of their special fields in defense of genetics" (p. 223).

Joravsky is not to be faulted for what his book was not designed to do, but we would have liked to be informed more fully of the way in which the broad but thin film of scientists, artists, and intellectuals has managed to be the source and sustenance of the illegal but loyal opposition. How does one account for the Medvedevs and Sakharovs and the paths which they have cut through the thicket? We would also have liked to know more of the ways in which the bureaucracy (increasingly infiltrated with scientists and technologists) was apparently converted into a counterforce to the Kremlin. And curiously enough, although the book abounds with allusions to economics (cf. pp. 12–13, 37, 195, 228, and 308), the otherwise fulsome index contains no references to the discipline. But in these matters we are not so much carping as expressing the hope that Joravsky has not yet called a halt to his labors.

As Joravsky sought to demonstrate, *The Lysenko Affair* is persuasive evidence of the utility and validity of current and recent history conceived and born outside of the comforting dark of the archives. Access to the archives would have eased his task, of course, but what Joravsky has done here in assessing the clash of science and political purpose might have been too soon arrested by the refuge of the official files. Forced to examine the course of events outside of the Kremlin and to trace their foreshadowings and reflections in party meetings, farms, research institutes, and the underground press of science, Joravsky catches the drama of the subornation of science by politics and power.

One may judge Joravsky's account to mean that science is not necessarily virtuous, but, if she is to yield her charms of truth, she can be brought most fruitfully to bed only on her own terms—a lesson the Kremlin learned slowly, reluctantly, and imperfectly.

JACK E. HOLMES AND STEPHEN OSOFSKY
University of Tennessee

Markham, Jesse W., and Gustav F. Papanek, eds., *Industrial Organization and Economic Development*, Boston, Houghton Mifflin Company, 1970, xiii + 422 pp.

This volume consists of 19 articles, written by former students of E. S. Mason in his honor. The articles are grouped into two parts; the first is entitled Industrial Organization and Public Policy and the second, Economic Development and International Trade. Each part will be discussed in turn but it should be noted straightaway that this volume has very little to say about the implications of industrial organization for the development of poor nations. This will likely be a disappointment to many prospective readers in agricultural economics.

Of the 13 articles in part I, three focus on methods and problems in industrial organization research (J. McKie, A. Phillips, J. Bain); two on antitrust policy and regulation (D. Turner, S. Loescher); and two on implications of uncertainty for performance of firms (J. Lintner, R. Caves). Also included are two case studies, one on world oil pricing (M. Adelman) and the other on international telecommunications (M. Peck). The remaining articles deal with growth of firms (R. Vernon), consumer behavior (R. Holton), joint bidding for offshore oil leases (J. Markham) and market structures and commodity taxes (R. Bishop).

Loescher gives a lengthy analysis of the 1911 Standard Oil case, arguing that it provides precedents for current legal theory of the anticompetitive effects of conglomerate mergers and for the allocation of antitrust resources in attacking illegal conglomerate mergers. In contrast to Turner's contribution, the analysis will be of interest mainly to the specialized reader.

Turner seems to draw very heavily on his experience in the Department of Justice. He argues that "any costs of applying divestiture remedies to economically significant monopolies and highly concentrated industries would be far outweighed by prospective gains." His assessment of the benefits consists mainly of citing researches by Bain and Collins and Preston; the literature using the concept of consumer surplus in measuring welfare losses is wholly ignored. His assessment of the costs are only somewhat more convincing. Turner also finds little to be pleased about regarding the effects of direct regulation; subsidy and protection fare even worse in his critique.

Adelman seeks to determine what one can learn about price theory by studying price determination in the world oil market and vice versa. In his usual sassy and provocative manner he (1) vigorously supports the profit maximization hypothesis; (2) insists that in analysis of industry, structure is little more than a check ("it is simply too imprecise") on conclusions drawn from behavior; and (3) pours cold water on Galbraith's substitution of planning by the technostructure for the unconscious planning of the market.

Turning briefly to some of the other articles, Peck not only sheds much light on current problems in the competition between cables and satellites in international telecommunications, but also provides evidence for Turner's thesis that direct regulation often leaves much to be desired. Caves argues that large companies with market power give up profits in favor of avoiding uncertainty; brief analysis of welfare effects is also given. The theoretical analysis by Lintner appears to open up many avenues for empirical research on the firm. Bain takes another look at the implications of the stability (or variability) of market structure for research. He explains once again his

earlier abandonment of Mason's very comprehensive concept of market structure (it includes everything except the kitchen sink) in favor of a concept that incorporates "a very few, supposedly leading" structural variables. In the opinion of the reviewer, the explanation still lacks cogency.

The second part of the book, about one-third the length of part I, begins with a broad overview of the subject of development economics (L. Reynolds). The remaining articles cover technical assistance (D. Bell); international capital markets (C. Kindleberger); industrialization through import substitution or exports (S. Robock); political economy in the Middle East (S. Alexander); and stabilization and monetary policy in less developed countries (E. Despres). Reynolds pooh-poohs the idea that such concepts as utility, production possibilities, and opportunity cost should be identified only with Western institutional settings but also concludes that "there *is* something new about development economics." Some hypotheses about early economic growth are offered. (In a discussion of transformation of politic-economic institutions nothing, strangely, is said about land tenure reform.) Alexander ends his article on a pessimistic note about the chances that Middle East conflicts can be settled without major setbacks in development. Kindleberger argues that a revival of international private lending is needed to supplement official aid and lending to developing countries.

In the preface the editors claim that the stream of literature on the monopoly problem was redirected in the early 1930's, with "the qualitative and conjectural pronouncements of an earlier era" giving way to "model building and factual analysis." Though progress doubtless has been substantial, much of the present literature is still characterized by what might be called "seat-of-the-pants" economics, and the same can be said for much of the work on economic development. In striving to provide "informed judgments" on issues of public concern, ad hoc theorizing, casual empiricism, qualitative conjectures, not to mention instincts, are frequently employed with relatively little attention given to rigorous analysis. Except for a few articles the present Festschrift does little to redress the balance.

This book covers a wide range of issues; some articles are tightly reasoned while others are subjective and impressionistic. Only limited use is made of mathematics and then only at an elementary level. Readers will recognize many of the authors as consummate scholars; the articles are generally of high quality. While several articles are rather specialized, most will likely be of general interest. The decision to include two groups of essays on disparate subjects was, in the opinion of this reviewer, a mistake.

PETER G. HELMBERGER
University of Wisconsin

Sargent, E. D., and S. J. Rogers, eds., *The Economic Prospects for Horticulture*, Edinburgh, Oliver and Boyd Publication 1970, XIII + 142 pp. (£1.50)

The book consists of ten papers presented at the Horticultural Conference held at Wye College, England, in March 1969. The papers were edited by Professors Sargent and Rogers of the Agricultural Adjustment Center, University of Newcastle-upon Tyne, the sponsoring agency.

The object of the horticultural conference at which the papers were presented was to review the problems and appraise the future of the horticultural industry in the United Kingdom. The assignment of topics to those who prepared the papers reflects the careful planning and efforts that went into the preparation for the conference. Collectively, the ten papers go far toward meeting the objectives of the planners of the conference. Moreover, they serve very well as a means of focusing public attention on current and relevant agricultural issues and problems, thereby creating an environment for a greater understanding of the dynamics of the horticultural industry in the United Kingdom.

A. R. Hunt and J. A. H. Nicholson, both lecturers in agricultural economics at Wye College in the University of London, wrote chapter 10, Postscript, which is basically a review and commentary on the other nine papers. In this excellent summary the authors highlighted these points from the conference papers:

1. United Kingdom horticultural producers will face increasing competition for the available land, manpower, and capital.
2. Mechanization of production and growing competition from overseas will complicate further the problems of small producers.
3. The interests of horticultural producers probably will be subordinated to the general public's interest in lower prices for imported products, especially if the United Kingdom enters the EEC.
4. Traditional marketing methods and channels are "decreasingly relevant to today's conditions."
5. Processors in the United Kingdom will be forced to seek a supply of lower cost raw products, probably from the continent.
6. The opposition of horticultural producer to a more free trade with EEC countries has proved ill-founded; and continued opposition may be a disservice to the industry, because the efforts of the industry should be spent in solving more basic problems of resource allocation.
7. The need for further cooperation among producers is apparent from both the marketing and supply procurement standpoints.

It is my judgment that anyone who purchases this book expecting a thorough treatment of the United Kingdom's horticultural industry will be disappointed. However, I think the series of ten conference papers goes far toward achieving the goal of improving public understanding and awareness of the

industry and its problems. That goal is a very important one.

D. B. DeLoach
University of California, Davis

Schuh, G. Edward, *The Agricultural Development of Brazil*, New York, Praeger Publisher, 1970, XXXIII + 456 pp. ($18.50)

The Agricultural Development of Brazil (*TADB*) has its origins in 1966. In that year the Ford Foundation commissioned a benchmark study or "diagnosis" of the past, present, and future of Brazilian agriculture and an inventory of research on the subject. This would be an extraordinarily difficult task in the best of circumstances. For Brazil, where economic analysis of agriculture has been meager and the data are spotty at best, a firm and interesting diagnosis of the sort commissioned is virtually impossible. When one attempts the impossible, one does not usually succeed. *TADB* is no exception.

TADB is very uneven. When Professor Schuh can draw on his own research, the discussion is often penetrating. His treatment of the operation of labor markets is interesting, while his evaluation of the educational research infrastructure is very useful for those seeking enlightenment in the subject.

Much of the time, however, Schuh engages in quantitative or verbal filibuster instead of discreetly accepting the silence indicated by inevitable ignorance. In his chapter on the structure of Brazilian agriculture (pp. 102–186), seemingly endless tables are substituted for analysis. Most of the discussion of public support for agriculture (pp. 260–292) is given to a bureaucratic description of organizational responsibilities (inevitably out-of-date, given Brazil's proclivity for bureaucratic "innovation"). Sixty pages are filled the Getulio Vargas Foundation's supply and demand projection (plus text) for 1965, 1970, and 1975. In retrospect these numbers illustrate the precariousness of all such forecasts, but they add little to our understanding of Brazilian agricultural problems.

Schuh's conclusions about the performance of Brazilian agriculture and the bulk of his policy recommendations are part of the conventional wisdom of American advisors in Brazil. Agriculture has grown satisfactorily but could have done better. Research should be increased and integrated with diffusion, education should be expanded, supply industries should be developed, etc., etc.

One remarkable aspect of *TADB*'s treatment of the "policy alternatives" (pp. 412–437) is that it contains no reference to *Brazilian* priorities as declared in several government plans.[1] Another aspect worthy of comment is Schuh's glib advocacy of policies with profound economic and social side effects which he does not explore. He does not see much need for a conventional land reform (pp. 415–416), although little evidence is presented either way. Schuh never makes the connection between landlessness and entry into the mass of the urban unemployed.

Schuh has great faith in the benign consequences of technological change for the poor in Brazil. He argues that productivity increases in agriculture, by reducing food prices, will change the income distribution in favor of the poorer classes (pp. 84, 425). He does not consider the possibility that the exact opposite result may occur in reasonable general equilibrium models. Money wages, in consequence of labor-saving technological change, may fall more than food prices weighted by the poor's expenditures on food. The nature of the technological diffusion process reenforces any tendency for downward pressure of the money incomes of the low income classes, particularly in the countryside. The poorer farmers are apt to be among the last to adopt a cost-reducing innovation, but they will feel its effects early in the form of lower prices. Schuh does not investigate this facet of the problem.

Furthermore, if policies to eliminate subsidies to capital in industry and to lower the effective cost of labor are implemented, Schuh sees no reason to retard labor-saving mechanization in agriculture (pp. 64, 427). He admits a serious employment problem might arise but considers the use of "agriculture as a residual employer" to be a "second best solution" which "should not be accepted" (p. 62). Schuh never tries to delineate the "first best" solution, let alone evaluate its feasibility. Rather, he urges Brazil to plow ahead. "The labor adjustment problem will just have to be faced by the appropriate means" (p. 427).

In spite of its obvious defects, *TADB* is a valuable encyclopedia or source book for secondary material and for data not otherwise available in one place. There are three limitations on this score: (1) Much of the material is out-of-date; (2) there is no index; (3) Schuh's footnoting of secondary material is incomplete. Thus it is sometimes difficult to know where Schuh ends and his secondary sources begin (for example, pp. 292–297).

Gordon W. Smith
Rice University

[1] Cf., for example, *Program de Acão Económico do Govêrno* (1964); *Programa Estratégico* (1968).

Books for listing in this section should be sent to the Book Review Editor (see inside front cover for address).

Books Received

Agro-Economic Research Centre for North East India, *Rural Life in Assam Hills; Case Studies of Four Villages;* Jorhat-4, Assam, Assam Agricultural University, 1969, 293 pp. Rs 15.00 paper.

Bailey, Martin J., *National Income and the Price Level, A Study in Macroeconomic Theory* 2nd ed., New York, McGraw-Hill Book Co., 1971, ix + 278 pp. $10.95.

Bilas, Richard A., and Richard S. Wallace, *Problems in Microeconomics,* New York, McGraw-Hill Book Co., 1971, viii + 255 pp. $5.50 paper.

Brown, Dorris D., *Agricultural Development in India's Districts,* Cambridge, Harvard University Press, 1971, xvi + 169 pp. $10.00.

Capstick, Margaret, *The Economics of Agriculture,* New York, St. Martin's Press, 1970, 163 pp. $6.00.

Clawson, Marion, *The Bureau of Land Management,* New York, Praeger Publishers, 1971, xiii + 209 pp. $8.50.

Corden, W. M., The Theory of Protection, New York, Oxford University Press, 1971, xiii + 263 pp. $8.00.

Dickinson, Frank G., *The Changing Position of Philanthropy in the American Economy,* National Bureau of Economic Research, New York, Columbia University Press, 1970, xi + 222 pp. $8.50.

Evenari, Michael, Leslie Shanan, and Naphtali Tadmor, *The Negev; The Challenge of a Desert,* Cambridge, Harvard University Press, 1971, x + 345 pp. $15.00.

Farcy, Henry de, *Economie Agricole,* Paris, Editions Sirey, 1970, 446 pp. 56F., postpaid 61F.

Food and Agriculture Organization of the United Nations, *Marketing Fruit and Vegetables,* 2d ed., revised, Rome, 1970, x + 181 pp. $3.00 or 24s Paper.

Food and Agriculture Organization of the United Nations, *Report of the Second World Food Congress; The Hague, Netherlands, 16–30 June 1970,* Vol. 1, Rome, 1970, vii + 141 pp. $2.50-20s-£1.00

Food and Agricultural Organization of the United Nations, *The State of Food and Agriculture 1970; World Review; Review by Regions; Agriculture at the Threshold of the Second Development Decade,* Rome, 1970, xii + 274 pp. $7.50-60s-£3. paper. paper.

James, L. Douglas, and Robert R. Lee, *Economics of Water Resources,* New York, McGraw-Hill Book Co., 1971, xviii + 615 pp. $16.50.

Johnson, Allen W., *Sharecroppers of the Sertao Economics and Dependence on a Brazilian Plantation,* Stanford, Stanford University Press, 1971, 153 pp. $6.95.

Johnson, E. A. J., *The Organization of Space in Developing Countries,* Cambridge, Harvard University Press, 1970 xv + 452 pp. $15.00.

Johnson, Warren A., *Public Parks on Private Land in England and Wales,* Baltimore, The Johns Hopkins Press, xv + 136 pp. $8.00.

Kuznets, Simon, *Economic Growth of Nations; Total Output and Production Structure,* Cambridge, The Belknap Press of Harvard University Press, 1971, xii + 363 pp. $15.00.

Labys, Walter C., and C. W. J. Granger, *Speculation, Hedging and Commodity Price Forecasts,* Lexington, Mass., D. C. Heath & Co., 1970, xxi + 320 pp. $15.00.

Mangahas, Mahar, Aida E. Recto, and Vernon W. Ruttan, *Production and Market Relationship for Rice and Corn in the Philippines;* Los Banos, Laguna, The International Rice Research Institute, University of the Philippines, 284 pp. Price unknown. Paper.

Mather, Loys L., *Economics of Consumer Protection,* Danville, The Interstate Printers & Publishers, Inc., 1971, viii + 148 pp. Price unknown. Paper.

Mendras, Henri, *The Vanishing Peasant, Innovations and Change in French Agriculture,* Cambridge, The MIT Press, 1970, x + 289 pp. $8.95.

Millar, James R., ed., *The Soviet Rural Commu-*

nity; A Symposium, Urbana, University of Illinois Press, 1971, xv + 420 pp. $12.50.

Organisation for Economic Co-Operation and Development, *Capital and Finance in Agriculture; General Report, Vol. 1,* Paris, France, 1970, 111 pp. $3.50-1.22-F16-Swfr. 14-DM11 paper.

Pathak, Mahesh T., and Arun S. Patel, *Agricultural Taxation in Gujarat,* New York, Asia Publishing House, 1970, x + 93 pp. $2.25.

Powell, John Duncan, *Political Mobilization of the Venezuelan Peasant,* Cambridge, Harvard University Press, 1971, 259 pp. $8.50.

Roy, Edward Van, *Economic Systems of Northern Thailand; Structure and Change,* Ithaca, Cornell University Press, 1971, x + 289 pp. $10.00.

Roy, Ewell P., Floyd L. Corty, and Gene D. Sullivan, *Economics: Applications to Agriculture and Agribusiness,* Danville, The Interstate Printers & Publishers, Inc., 1971, 455 pp. $7.95.

Schultz, Theodore W., *Investment in Human Capital; The Role of Education and of Research,* New York, The Free Press, 1971, xii + 272 pp. $8.75.

Shirlaw, Gilchrist, D. W., *An Agricultural Geography of Great Britain,* New York, Pergamon Press Inc., 1966, ix + 162 pp. £1.75, $5.50, flexicover £1.25, $4.00.

Soth, Lauren, ed., *The 70's Challenge and Opportunity,* Ames, The Iowa State University Press, 1970, ix + 91 pp. $3.95.

Stewart, Ian M. T., *Information in The Cereals Market,* London, Hutchinson and Co., Ltd., 1970, xvi + 430 pp. £3.

Tewari, R. N., *Agricultural Development and Population Growth; An Analysis of Regional Trends in U.P.,* Delhi, Sultan Chand and Sons, 226 pp. Rs. 25.00, 37.5sh, $5.00.

Thompson Gerald E., *Linear Programming; An Elementary Introduction,* New York, The Macmillan Company, 1971, vi + 384 pp. Price unknown.

Wilkie, Raymond, *San Miguel: A Mexican Collective Ejido,* Stanford, Stanford University Press, 1971, xvii + 190 pp. $7.50.

Willrich, Ted L., and George E. Smith, eds., *Agricultural Practices and Water Quality,* Ames, Iowa State University Press, 1969, xxvii + 415 pp. $7.95.

Volin, Lazar, *A Century of Russian Agriculture from Alexander II to Khrushchev,* Cambridge, Harvard University Press, 1970, viii + 644 pp. $18.50.

Wood-Ritsatakis, Anne, *Analysis of the Health and Welfare Services in Greece; Special Studies Series B,* Athens, Center of Planning and Economic Research, 1970, 227 pp. Price unknown. Paper.

Announcements

CHANGE OF EDITORSHIP OF AJAE

Starting with the February 1972 issue, the new editorial staff of the American Journal of Agricultural Economics will be:

Editor—LEO POLOPOLUS
Associate Editor—MAX R. LANGHAM
Book Review Editor—PETER G. HELMBERGER

New submissions of manuscripts should now be sent to Leo Polopolus, Department of Agricultural Economics, University of Florida, Gainesville, Florida 32601. Communications concerning books for review should be addressed to Peter G. Helmberger, Department of Agricultural Economics, University of Wisconsin, Madison, Wisconsin 53706.

WINTER MEETING
AMERICAN AGRICULTURAL ECONOMICS ASSOCIATION WITH ALLIED SOCIAL SCIENCE ASSOCIATIONS

December 27–30, 1971
New Orleans, Louisiana

The winter meeting of the American Agricultural Economics Association will be held in conjunction with the Allied Social Science meetings in New Orleans, December 27–30, 1971. A complete program will be published in the November issue giving details on topics and speakers.

Sessions are scheduled as follows:

Economic Growth and Rural Poverty (Joint session with American Economics Association)
Process Analysis and the Economics of Production (Joint session with American Econometric Society)
The Theory of the Firm in a Nonmarket Environment

1972 AAEA ANNUAL MEETING

The 1972 annual meeting of the American Agricultural Economics Association will be held at the University of Florida, Gainesville, Florida, August 20-23, 1972. Please send program suggestions to Vernon W. Ruttan, Department of Agricultural Economics, University of Minnesota, St. Paul, Minnesota 55101.

MEETING ANNOUNCEMENT AND CALL FOR PAPERS "COMPUTER SCIENCE AND STATISTICS: FIFTH ANNUAL SYMPOSIUM ON THE INTERFACE" OKLAHOMA STATE UNIVERSITY, NOVEMBER 1 AND 2, 1971

A two-day meeting will be held at Stillwater, Oklahoma, open to all those who are interested in the relationships between computer science and statistics. The keynote speaker will be H. O. Hartley of Texas A&M University. Concurrent workshops will be:

Time Series and Stochastic Processes: Emanuel Parzen, State University of New York, Buffalo, chairman
Decision Sciences: Dennis Grawoig, Georgia State University, Atlanta, chairman

Compumetrics: Robert Gordon, University of California, Irvine, chairman

Computer Science and Statistics in Higher Education: J. L. Folks, Oklahoma State University, and Ron Mohler, University of Oklahoma, co-chairmen

Computer Science and Statistics in the Extractive Industries

Persons having papers in any of these five areas (up to about eight pages) are invited to submit them to Dr. Mitchell O. Locks, Oklahoma State Univer-sity, Stillwater, Oklahoma 74074; to be considere for presentation and for possible incorporation int the proceedings. A complete paper is preferable to a abstract for this purpose. Anyone wishing a confe ence brochure may request it of Dr. Locks.

This conference is co-sponsored by Oklahom State University, the University of Oklahoma, Nort Texas State University, and the University of Tulsa and some midcontinent industrial firms.

News Notes

UNIVERSITY OF CONNECTICUT

APPOINTMENT: **Raymond O. P. Farrish**, head of department, succeeding **Stanley K. Seaver**, department head since 1963, who returns to research and teaching.

CORNELL UNIVERSITY

APPOINTMENT: **Harry P. Mapp, Jr., Ph.D.** Oklahoma State, assistant professor.

AWARDS AND HONORS: **David J. Allee**, Presidential Citation, for his part in a scientific study which formed the basis of an ecological report on Cayuga Lake; **Stanley W. Warren**, Agricultural Counselor Award from the Farm Credit Banks of Springfield.

ECONOMIC RESEARCH SERVICE, USDA

(FDTD is Foreign Development and Trade Division; FPED is Farm Production and Economics Division; FRAD is Foreign Regional Analysis Division; NRED is Natural Resource Economics Division.)

APPOINTMENTS: **Klaus F. Alt**, FPED, Ames, Iowa; **Angel O. Byrne**, Communist Areas Analysis Section, Europe and Soviet Union Branch, FRAD, Washington, D.C.; **Leonard Bull, Philip L. Luxenburger,** and **Merritt Padgett**, NRED, East Lansing, Michigan; **Lynn M. Daft**, returned from detail to OEO, assistant deputy administrator; **Ralph G. Forsht**, NRED, University Park, Pennsylvania; **Reed E. Friend,** assistant chief of Far East Branch, FRAD; **Lawrence A. Jones**, acting chief of Agricultural Finance Branch, FPED; **William E. Kost** and **David E. Kunkle**, FDTD; **John E. Lee, Jr.**, director of FPED; **John Sutton**, NRED, Washington, D. C.

TRANSFERS: **Philip T. Allen,** from FDTD to FPED, Washington, D. C.; **Melvin Bellinger** and **Adrian Haught**, NRED, to Forest Service, Washington, D. C.; **Paige I. Bryan**, FRAD, to Radio Liberty, Munich, Germany; **Percy Luney,** NRED, to Office of Secretary of Agriculture as chief of Program Evaluation Staff, Civil Rights Staff; **Philip L. Mackie,** FRAD, to Foreign Agricultural Service, Washington, D.C.

RESIGNATIONS: **Gary Gettel**, NRED, East Lansing, Michigan; **Russel Gum**, FPED, Tucson, Arizona; **Stanley Miller,** NRED, to consulting firm in Venezuela; **Margaret B. Missiaen**, FRAD, to Senator Muskie's staff.

HONORS: **Raymond P. Christensen**, FDTD director, nominated for National Civil Service League's 1971 Career Service Award.

UNIVERSITY OF MINNESOTA

APPOINTMENTS: **Wesley B. Sundquist**, formerly deputy administrator, Economic Research, USDA, head of department; **Earl I. Fuller,** formerly of the University of Massachusetts, professor and extension economist.

LEAVES: **Martin E. Abel**, returned from two-year assignment in India as program adviser in agricultural economics under a Ford Foundation grant; **James P. Houck**, to Agricultural Economics Department, Kasetsart University, Bangkok, Thailand, under University of Minnesota-Rockefeller Foundation grant, 1971–72.

HONORS: **Truman R. Nodland**, FarmHouse Fraternity "Outstanding Alumnus" award, first such award in Minnesota.

UNIVERSITY OF MISSOURI

APPOINTMENT: **Charles L. Cramer**, department chairman, succeeding **V. James Rhodes,** who returns to full-time teaching and research.

NORTH CAROLINA STATE UNIVERSITY

APPOINTMENTS: **Charles Richard Shumway, Jr.**, assistant professor in economics, and **A. Ronald Gallant**, visiting professor in economics and statistics.

STANFORD RESEARCH INSTITUTE

APPOINTMENTS: **Robert E. Olson**, director of Food and Industries Program in Economics Division; **William Bredo,** formerly director of Development Economics and Agroindustries Program, director of International Development Center; **Peter D. Stent**, agricultural economist.

RESIGNATIONS: **Alan R. Thodey**, agricultural economist, to Ford Foundation in Department of Agriculture, University of Chiang Mai, Thailand; **Robert C. Brown**, economist, to Farmer Cooperative Service, USDA, Washington, D.C.

WASHINGTON STATE UNIVERSITY

APPOINTMENT: **Donald R. Levi**, University of Missouri, research and teaching faculty, one year.

LEAVE: **Laszlo Valko,** to Europe for research on cooperative legislation, one year.

RESIGNATION: **Eldon E. Weeks,** to Economic Research Service, USDA, as chief of Farm Income Branch, Economic and Statistical Division.

RETIREMENT: **Karl Hobson,** after more than 21 years on the faculty.

OTHER APPOINTMENTS

Sung Hwang Ban, Ph. D. Minnesota, assistant professor of agricultural economics, Seoul National University, Suwon, Korea.

Herman Eggers, M.S. Missouri, economist, Federal Land Bank, Omaha, Nebraska.

James Greer, formerly of the University of Nebraska, Ralston Purina Company, St. Louis, Missouri.

Frederick J. Hitzhusen, Ph.D. Cornell, assistant professor, Ohio State University.

Richard C. Hoyt, Ph.D. Minnesota, president of Tennant and Hoyt, Lake City, Minnesota.

Nicholas B. Lilwall, Ph.D. Minnesota, agricultural economist, Edinburgh School of Business, Edinburgh, Scotland.

Edierth Restrepo, M.S. Missouri, Centro Nacional De Investigaciones Agropecuarias "Tibaitata," Bogota, Colombia.

Jerry W. Robinson, Jr., formerly of the Houston Baptist College, associate professor of rural sociology, University of Illinois.

Roderigo Tascon, M.S. Missouri, Centro Nacional De Investigaciones Agropecuarias "Tibaitata," Bogota, Colombia.

OTHER RETIREMENTS

Ralph Sherman, professor, Ohio State University, after 42 years of service.

OTHER AWARDS

Calvin R. Berry, University of Arkansas, Distinguished Service Award, from Associated Milk Producers, Inc., in recognition and appreciation of his dedicated service to the dairy industry as a member of the Dairy Marketing Advisory Committee.

OBITUARIES

Bennett A. Dominick, Jr., 50, professor of marketing at Cornell University, died in April 1971. Born in South Carolina, Professor Dominick was reared on a dairy and citrus farm near Orlando, Florida. He was graduated from the University of Florida in 1943. After military service he remained in Europe in 1946 and 1947 as Assistant Chief of Food, Agriculture, and Forestry in the Military Government at Salzburg. He received his M.S. and Ph. D. degrees at Cornell and joined the faculty in 1951.

In his dissertation research Professor Dominick pioneered in experimental design to measure the effects of various practices on consumer purchases. Over the years he kept his hand in research related to production and marketing of fruits and taught a course in marketing, but his primary responsibility was in extension. At the time of his death he was extension leader in agricultural economics at Cornell and chairman of the Northeast Regional Extension Marketing Committee and had served nationally on the Agriculture, Marketing, and Related Industries Committee of the Extension Committee on Organization and Policy of the Land-Grant College Association.

Winn F. Finner, 57, career USDA official and associate administrator of USDA's Consumer and Marketing Service from 1967 to 1969, died in April 1971. He began his USDA career in 1937 with the Agricultural Adjustment Administration and transferred to the Bureau of Agricultural Economics in 1939. He was associated with USDA's statistical and economic research programs until 1967, except for a three-year period in the U. S. Navy during World War II. During 1961 he was on special assignment in Jamaica for the Food and Agriculture Organization and was primarily concerned with improving the island's farm marketing system. Following his retirement as associate administrator of the Consumer and Marketing Service in July 1969, he went with Ford Foundation in New Delhi.

Born in Cassville, Wisconsin, Finner attended the Universities of Florida and Wisconsin, receiving the B.S. degree in 1934 and the Ph.D. degree in 1948 from Wisconsin. He was a member of the American Agricultural Economics Association, was a fellow in the American Association for the Advancement of Science, and received USDA's Distinguished Service Award in 1967. He was well-known and respected by agricultural economists throughout the United States because of his work with land-grant colleges in the administration of USDA marketing research programs and his active participation in the American Agricultural Economics Association.

David N. Fox, son of Mr. and Mrs. Stanley T. Fox of Dryden, New York, was killed in action in Southeast Asia on February 8, 1971. A graduate of Cornell University in 1967, Captain Fox had planned to continue his studies in resource economics at the University of New Hampshire. He is survived by his wife and a daughter born two weeks after his death.

Gad Parker Scoville, professor emeritus of farm management at Cornell University, died in St. Petersburg, Florida, in March 1971, in his 86th year.

Professor Scoville was a charter member of the Association. In 1912–1914, as the first county agent in Chemung County, New York, he pio-

neered extension programs in farm management. His work attracted the attention of USDA officials who proposed a joint appointment with the College of Agriculture where he could teach extension workers from other states. He moved his headquarters to Cornell University in 1914 and shifted much of his work to research on the economics of production and marketing of fruit crops. He also initiated a course that emphasized farm business analysis and solutions to management problems.

Professor Scoville was born at Varysburg, New York, in 1855 and was graduated from Cornell in 1910. He taught high school in Fresno, California, for two years before entering the Extension Service. He was awarded the M.A. degree by Harvard University in 1922. He retired from Cornell in 1953 and made his home near Goshen, New York, and subsequently in Florida.

Canadian Journal of Agricultural Economics

Volume 18, No. 3 November/novembre 1970

ARTICLES

With Notes, Book Reviews and Announcements

The Canadian Journal of Agricultural Economics is published by the Canadian Agricultural Economics Society. Annual dues or subscriptions are $10.00. Address editorial communications to M. H. Hawkins, Editor, Dept. of Agricultural Economics, University of Alberta, Edmonton 7, Alberta, Canada.

JOURNAL OF AGRICULTURAL ECONOMICS

Vol. XXII, No. 1 January 1971

Contents

With Reviews, etc.

Journal of
THE AGRICULTURAL ECONOMICS SOCIETY

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Editor: O. J. Beilby, Department of Agriculture and Fisheries for Scotland, St. Andrew's House, Edinburgh, EH1 3DA, Scotland.

Treasurer: Ian G. Reid, Department of Agricultural Economics, Wye College, Ashford, Kent, to whom all enquiries regarding membership of the Society and orders for Journals should be sent.

american journal of agricultural economics

AAEA Winter Meeting
New Orleans, Louisiana
December 27-30, 1971

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AMERICAN JOURNAL OF AGRICULTURAL ECONOMICS

EDITORIAL COMMUNICATIONS

Editorial communications, including manuscripts submitted for publication or inquiries concerning the JOURNAL, should be addressed to Leo Polopolus, Department of Agricultural Economics, University of Florida, Gainesville, Florida 32601.

Communications concerning books for review and books submitted for announcement in the JOURNAL should be addressed to Peter G. Helmberger, Department of Agricultural Economics, University of Wisconsin, Madison, Wisconsin 53706.

SUBSCRIPTIONS

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- Subscriptions, orders for individual copies of the JOURNAL and changes of address of subscribers should be addressed to John C. Redman, Department of Agricultural Economics, University of Kentucky, Lexington, Kentucky 40506.

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The University in Contemporary Society*

Emery N. Castle

The paradox currently facing higher education can be stated in terms of the inherent elements of competition between the autonomous and popular functions of the university. Land-grant universities and academic agricultural economists are inevitably caught up in this competition and need to come to terms with it. In coming to terms with this conflict, academic people will find it helpful to recognize and admit the social consequences of their mission-oriented research and service. They also need to recognize internal threats to academic freedom; not all such threats come from irate citizens or the corrupting impact of the establishment. The federal-state relationship in research is undergoing significant change. Management techniques are "in"; individual freedom in choice of research project and procedure is "out". The implications of this for the traditional and autonomous functions of the university has been neither widely recognized nor discussed.

The objective of this paper is to state the paradox facing higher education from the vantage point of the economic concept of product mix, with particular attention to the implications for issues in agricultural economics.

I have found the best statement of the paradox in a recent Daedalus article by Martin Trow, entitled "Reflections on the Transition from Mass to Universal Education" [19]. The dichotomy he sets forth has relevance to the land-grant universities and to any university or college that is involved in mass or universal higher education. According to Trow, the paradox can be stated in terms of the tension existing between the autonomous and the popular functions of the traditional university. The autonomous functions, he says, include (1) conservation and transmission of high culture; (2) pure scholarship and basic scientific research; and (3) selection, formation, and certification of elite groups. The popular functions fall into two general categories: (1) a commitment to provide places for as many students as can be encouraged to continue their education beyond high school, and (2) provision of useful knowledge and service to every group and institution that wants it. It is obvious to any observer that demands for the performance of the popular function have increased dramatically in this country in recent decades.

Land-grant universities were created in the popular tradition and were designed to provide an education for those who did not have the opportunity for education in the more classic tradition.[1] The service function was explicitly recognized later by the funding of research and extension activity. Yet the autonomous functions of the university were never completely absent from land-grant universities. Certainly today the autonomous functions are attributed considerable importance; indeed, academic prestige and status are often accorded in rather direct relationship to excellence in the performance of the autonomous functions.

Conflict and tension will inevitably result when a university tries to serve both traditions. The root question then is: Under what circumstances will this tension and conflict become constructive and under what circumstances will it become destructive? A potentially destructive situation exists when the larger society is evaluating the university in terms of one tradition while the university is pursuing another, or when members of the university community are in fundamental disagreement as to which function they are to serve. A constructive situation prevails when there is recognition of the potential inconsistency of the two traditions but recognition also of the self-reinforcing nature of each to the other. Ideally this dual recognition should prevail both within and outside the university. The worst kind of

* Originally presented to the Western Agricultural Economics Association in Tucson, Arizona, July 1970. That paper was a direct outgrowth of one year's service on the President's Commission on University Goals, Oregon State University. It is impossible to identify the source of all the ideas and material presented; much is the result of extended conversations with my two colleagues, James Knudsen, Assistant Dean of Engineering, and Warren Hovland, Chairman, Department of Religious Studies, Oregon State University, who, with me, comprised the three-man commission. I am also indebted to John Edwards, Herbert Stoevener, Richard Johnston, and Frank Conklin for penetrating comments on an earlier draft of this paper.

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[1] The same can be said for certain other public universities although, unless otherwise indicated, this discussion will apply to the land-grant universities.

folly is to fail to recognize that the two functions are potentially competitive; this constitutes a violation of one of the most elementary principles of enterprise selection. What then are the arguments for and against the production of two products? In organizing and marshaling these arguments we must look both within and outside the universities, because both the production possibilities and the choice indicators are important. We shall treat first the outside influence.[2]

The easy answer is that Americans expect both products from higher education. It is obvious that they expect the popular functions as they have been willing to tax themselves for these services. It is not so clear that they are as enthusiastic about the autonomous functions, but the greatest prestige seems to reside with those educational institutions that are best recognized for the excellence with which they perform the autonomous functions. The evidence suggests further that we prefer to leave the autonomous functions more to the private colleges and universities and that relatively greater weight is given to the popular functions by public universities [19]. I shall proceed on the assumption that both functions have utility to the larger society and carry a positive shadow price.

To obtain a more precise concept of what might constitute a desirable mix one must also look within the universities. The performance of both functions does not mean necessarily that both will be emphasized by every institution to the same extent. One might expect to find, as indeed one does, different degrees of emphasis as one moves from the community colleges to the more elite private institutions. Yet the large universities, both private and public, strive for both products. Will they have to make a choice, or do the production possibility function and the choice indicators suggest that they should continue to try to do both?[3]

Trow [19] argues that the University of California at Berkeley should attempt to emphasize the autonomous functions. He believes that the dangers are tremendous if the popular service function is embarked upon; that the university will then become a pawn in the political arena. In other words, he believes the governing structure will be affected to the point that the autonomous functions cannot be performed. Yet we cannot turn back the clock. It is my opinion that the large public universities are irrevocably committed to the popular functions of education and service. If they must sacrifice something, it will be their autonomous functions. If the universities are to become "pure" universities in the sense of emphasizing only the autonomous functions, we shall have to start over. Both the internal power structure and the interconnections with the larger society are such that I cannot foresee the abandonment of the popular functions [11].

Will the universities go to the extreme of giving emphasis only to the popular functions? It is conceivable that they will attempt to be so responsive to popular demands that the academic traditions associated with the autonomous functions will be sacrificed. Indeed, if only the popular functions are emphasized there would be little further need for some of the existing academic traditions. For example, we could expect academic freedom, as currently exercised, to change considerably.

One of the real myths of higher education is the notion that land-grant universities mainly do mission-oriented research and service while the other large universities, public and private, are concerned mainly with the autonomous functions. Such a conclusion is a gross oversimplification. There is some evidence that John Kennedy tended to view Harvard Uni-

[2] Explicit recognition should be given to the fact that an educational effort is seldom completely autonomous; that is, it is designed to satisfy some clientele and is never completely independent of some outside influence. By the same token, "useful" and "popular" educational functions will almost always have by-products comparable to what Trow classifies as the output of autonomous educational functions. The extremes would be exceedingly difficult, if not impossible, to attain in practice, and the "relevant range" really involves the relative emphasis that is placed on the two functions. Nevertheless, I believe this discussion can best be advanced by a discussion of the two extremes prior to the more precise problem of determining where, within the relevant range, we will produce.

[3] One might define products differently (say) as teaching, research, and service. That the real enemy of good teaching is research is a subject much discussed lately. Trow points out that both the far left and the far right are united on this issue and believe that if research were eliminated student unrest would tend to disappear. This subject is of sufficient importance to be examined in depth; I have chosen to focus this paper on other issues. Nevertheless, I believe this is too naive a view of the cause of student unrest. Furthermore, while it is sparse, the available evidence gives little support to the contention that research is the enemy of teaching that frequently it is assumed to be. In addition, student unrest exists in college and university settings where there is little research.

versity as his personal extension service. The National Science Foundation's current emphasis on "applied" and interdisciplinary research is not so much a shift from basic to applied research as it is recognition that social problems are changing and that a different kind of research is needed if tax dollars are to continue to be extracted for this purpose. Scientific workers may believe we have shifted from basic to applied research, but it is not clear that those who are providing the funding or those whose principal function is to obtain funding are so deluded.[4] The problems of the land-grant universities are part of the total policy issue facing higher education in the United States.

If we cannot and will not shed ourselves of the popular service function, can we escape the inherent dangers that may result in our becoming a tool of the ruling group or being destroyed in our efforts to prevent this from happening? The answer will depend in part, but not entirely, on the policies and procedures of institutions of higher education during this crisis period.

Policies and Procedures in Institutions of Higher Education

When a research or educational project is chosen there are inevitable social consequences. These choices and their consequences are value-loaded. To ignore them or to pretend that such choices have no value implications is most irresponsible. Whether such value choices are made within or outside the university or by some interaction of the two is a question of the degree of direction by society of the university. But when university people make these choices they should: (1) be aware of the value implications, (2) accept responsibility for their decisions, and (3) communicate with the larger community regarding the probable consequences of the application of research findings.

Scientific objectivity is something very different [4]. It can be defined in terms of the method of inquiry and may serve as an ideal. When an area of investigation is such that replication and verification are difficult, objectivity as a guide to scholarship and inquiry is more important than when these procedures can be followed easily. When they can be followed easily, a dishonest or biased scientist is in great danger of being exposed by his colleagues. As agricultural economists move more in the direction of multidisciplinary and mission-oriented research, greater rather than less emphasis may need to be placed on the philosophical base of research methodology and the social consequences of the application of research results. If we emphasize these features in our graduate education, the result will be better scientists who will also be more "relevant."[5]

Another factor contributing to the crisis of confidence in the scientific community has been the failure of scientists to communicate with the public regarding the indirect or second- and third-round effects of the application of their newly discovered knowledge. In many instances the actual effect may still be unknown, but even the theoretical possibilities have not been discussed thoroughly. At the present time the university community is being asked to give attention to some of our most severe social problems. Yet it is a rare social science that has been able to pose hypotheses capable of being refuted. Under these circumstances we not only run the risk of being wrong and causing harm, we also risk a loss of confidence in everything we do. By our silence we often imply that we can do that which we cannot, and we then accept funds with the implied promise that we will obtain useful results. Administrators need not apologize for accepting funds for high-risk projects, but they should identify two types of uncertainty: (1) that which is related to project results; (2) that which is related to the consequences resulting from the application of knowledge. Given the massive nature of the social problems we are currently asked to tackle, the rudimentary nature of our knowledge, and the level of funding contemplated, there appears to be need for some words of caution.

Although agricultural economists may wish to point to agronomists, horticulturists, and entomologists as the chief offenders in this respect, our own record is far from bright. We have been highly preoccupied with firm and market economics and have largely neglected the concepts of externalities until less than a decade ago. (I include myself among those who neglected indirect effects in much research.) We may answer that we are doing much better now with our more powerful tools of analysis,

[4] I am indebted to James Hildreth for some of the thoughts in this paragraph.

[5] Glenn Johnson [12] makes this same point and illustrates the consequences of unthought-out combinations of philosophic positions in the contemporary scene.

such as simulation techniques. I submit, however, that our capacity for misleading the public has increased in direct relation to the complexity of these techniques. For example, the omission of a key variable can render results meaningless or misleading. Yet our literature provides numerous examples of such oversights.

Academic Freedom and Institutional Neutrality

When both the popular and autonomous functions of the university are embraced, there will always be an uneasy tension between social responsiveness and academic freedom. The choice of projects may be a joint responsibility of client and researcher, but freedom of the academic person to choose the methods of investigation, to test, and to publish is essential to investigative integrity. This becomes complicated by an additional issue. If the institution, as an institution, becomes committed to a position on public issues, it risks a loss of public confidence and the threat to academic freedom is great indeed. Professional schools, in particular, must avoid being captured by an industry or a profession. If they become the tool of an interest group, their research and their teaching will not be taken seriously; the corollary is that those scholars who are committed to the academic tradition will find such an atmosphere hostile [15].

It would be the worst kind of academic myopia to assume that threats to academic freedom always come from outside the university and from those who wish to maintain the status quo in society. Those of us who are in closest contact with the popular functions of the university and who tend to be associated with particular industry groups should be alert to outside threats. Yet examples abound of academic people who have become so committed to the objective of social change that any evidence supporting stability or the status quo is not admitted in dialogue or investigation. The academic community will rise in wrath if a far-left speaker is denied a platform on a university campus. Yet they remain strangely silent when a program is structured to present a particular point of view or when a person of conservative view is not permitted to speak in public meetings.[6]

Product Mix and Public Decision-Making

It is appropriate that agricultural economists take the lead in discussing the product mix issue. Our profession suggests both a mission (popular function) and a discipline (autonomous function). The subject is far too deep and complex to analyze thoroughly in this paper. I have tried to treat some of the organizational issues elsewhere [6], as has Glenn Johnson [12].

If one views the entire educational establishment in the United States, the impression is created of a highly complex system providing for service at many levels and for a wide variety of "mixes." However, when one observes decision-making within an educational system one observes forces working toward homogeneity of the institutions. Community and junior colleges aspire to be four-year institutions. Four-year institutions wish to do research and public service. Undergraduate colleges lust for graduate work. It is difficult to distinguish the land-grant universities from other large public universities. It is also difficult to distinguish between "public" and "private" universities.

Nevertheless, diversity does exist and decisions are constantly made. The outline for the kinds of needed analysis is very clear. Fundamental to any inquiry is the need to specify the level of aggregation being assumed. At the

[6] Relative to the autonomous and popular functions, it is not clear that social change should be an educational objective, although it is an obvious result of education. It is clear that the performance of either the autonomous or the popular function of education will result in social change. Inconsistent value systems, inefficient social institutions, and unapplied knowledge are all legitimate subjects for classroom and research analysis. Yet that is very different from a commitment of an educational institution to change, per se. If this or any other noneducational objective becomes paramount, it is not surprising that the ideals of objectivity and the pursuit of truth suffer.

Warren Hovland has asked, "Does the university ever properly take a public stand on a public issue?" The question poses an exceedingly difficult dilemma. When a university does so, it may expect a reprisal from some segment of society and the prospect of loss of autonomy. On the other hand, when the consequences of a particular policy choice are judged to be disastrous to the future of the society of which the university is a part, the cost of remaining silent may also be great. The best I can do with the dilemma is to say that one simply has to judge which course of action is most costly and then choose. If this line of argument is accepted, it follows that a public stance on a public issue is indeed rare but is not precluded. A university is a complex institution and a judgment as to whether a particular policy is likely to be "disastrous" is indeed dangerous and difficult.

For an exception to the position taken in this footnote, see Loy Sammet's excellent discussion of my WAEA paper [17].

most general level it would be helpful to know the social rate of return from various kinds of education, research, and service activities. Economists at the University of Chicago have been leaders in making measurements that are especially valuable to those in a position to view alternatives broadly, such as legislators or university boards.

Within the educational establishment product-mix choices have to be made at almost every level of administration. Currently operation research techniques are in vogue and are likely to bring about a quiet revolution in university administration. Arguments are likely to be highly polemical on this subject. The strongest proponents have little apparent regard for the traditional institutional decision processes. The traditionalists tend to view with absolute horror the application of cost-effectiveness to educational processes.

If economists take advantage of this new opportunity for service, many of those principles that have been shown to be necessary to success in our traditional research areas will continue to serve us well. We should not claim more for our tools than they are capable of delivering. In particular, we should attempt to rid both the profession and our clients of the notion that we are capable of measuring "optimality." The economist knows some of the theoretical pitfalls associated with the indiscriminate use of cost-effectiveness, cost-benefit, and mathematical programming. He should make these pitfalls known to others. It is just as important to avoid being "captured" from within the university as it is to avoid being captured by an industry group outside the university. The economist should refuse to do such research unless he is free to pose hypotheses, to test as he sees fit, and to make the results known.

Mission-Oriented Research in the Autonomous University

Academic agricultural economists, with other agricultural scientists, are fast approaching a showdown regarding their mission-oriented research and their academic roles. There is considerable evidence that the complex federal-state research relationship is being revised to provide the tools for the "management" of research on a national level. Priorities of problem areas are being agreed to, research problem areas are specified, and funds are allocated accordingly.[7] The stage is being set for the evaluation of performance in terms of contribution to previously agreed-upon objectives and problems. Institutional structures of federal-state relations in this field are undergoing subtle changes in order to permit the new tools of management to be effective.

If we accept the popular version of our research role, such a procedure may make some superficial logic. The institutions and processes outside the university are relied upon to define the product and the researcher does his best to create this product. Yet concern and bewilderment pertaining to such an approach seem to increase in direct proportion to the distance one gets from the center of power and the origin of financing.

Up to this time the discussion has been largely in terms of a power struggle between the federal and state establishments. Yet to my knowledge there has been little fundamental discussion of the impact of an imposed uniformity on the long-run quality of research. Nor has the practical value to society of a degree of autonomy been given much attention. The reduced diversity of research effort will reduce fragmentation and duplication; it may also reduce our ability to move rapidly and to anticipate needs.

There has been considerable discussion as to whether graduate students, acting as research assistants, are the most efficient personnel in the accomplishment of mission-oriented research. The question is a valid one. An equally valid question, however, is the relative weights that should be given to the results of the research and the training of graduate students. To state the question differently, one might ask whether the conduct of mission-oriented research is an efficient way to provide research experience in the education of graduate students.

It is my opinion that the stress between the popular and autonomous functions within agricultural economics will become increasingly severe during this decade. It is also my opinion that much will be lost if we permit either product to become dominant for any significant period of time. The two are mutually reinforcing; their combination permits the power and

[7] Funds are being shifted among research problem areas although geographic distribution to this time remains largely on a formula basis (unless current emphasis on regional centers and regionalism is viewed as an exception).

beauty of science to be combined with the desire of the concerned person to be relevant and to be of service. At the state and local levels a fully involved and coordinated extension program may provide in part a satisfactory buffer against overemphasis on the popular function. But no such buffer exists at the national level. If a combination of the two products is to continue to be produced by agricultural economics departments within universities, the value of both products must be recognized. Different organizational forms will probably be more efficient if production of either product is the primary objective. Academic agricultural economists need to turn their demonstrated power of analysis to this central issue as their universities struggle to fill the dual roles that society expects of them.

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University-Agribusiness Cooperation: Current Problems and Prognosis*

W. D. Dobson and Robert C. Matthes

Developments discussed in this paper point toward decreased opportunities for cooperation between university agricultural economists and agribusiness officials and economists. The basis for cooperation is becoming substantially lower. In the future operators of small and medium-size agribusiness firms will need larger amounts of technical assistance to incorporate essential new management techniques. Although this would involve controversial firm specific work, we argue that university agricultural economists should help to provide the technical assistance required by these firms. This cooperative effort should produce public benefits, healthier small and medium-size agribusiness firms, and support for the agricultural college. Joint effort is needed to improve agribusiness training programs in universities.

Developments that threaten to reduce the amount of cooperation between university-based agricultural economists and agribusiness officials and economists may be grouped into two categories: structural-competitive developments and transitional developments. Those in the first category arise from changes in size and competitive activities of agribusiness firms; those in the second apparently stem partly from neglect of the needs of agribusiness by agricultural economists within universities. The objectives of this paper are to examine implications of these changes and to identify feasible forms of cooperation. Our examination of these topics is based in part on experiences and practices of FS Services, a regional farm supply cooperative which serves farmers in Illinois, Wisconsin, and Iowa.

Structural-Competitive Developments

Emergence of the large, self-sufficient agribusiness firm is a structural development that has reduced the basis for cooperation. According to Stanton [25, p. 2], direct reliance on universities (or any outside agent) for advice and information is contrary to natural processes within larger firms that have developed internal research and service organizations.[1] Many large agribusiness firms have established internal research groups of the type Stanton mentions and thus are able to obtain research findings quickly and without disclosing the nature of company operations. When large agribusiness firms need outside aid, they may seek help from a private consulting firm, government agency, business school, or agricultural economics department—whichever is best suited for the job. The private consulting firm is an attractive source of aid because it can produce results quickly and without public disclosure of its findings. Opportunities for work by the university agricultural economist with the larger agribusiness firms in particular are lessened by the existence of the internal research group and other competitors, some of whom are better equipped to assist these firms.

According to Bauder and Parr [2, p. 80], when large agribusiness firms recruit new employees little preference is shown for persons with farm backgrounds.[2] Their findings are consistent with hiring practices followed at FS Services and other larger agribusiness firms. For example, when FS Services interviews persons for a research staff position or an administrative job, rarely does an applicant's farm background determine that he will be offered the job in preference to another applicant.[3] The recruiting practices of larger agribusiness firms, we believe, are changing the composition of executive leadership in those firms to include more people with business school training and fewer people with agricultural training. Executives with business school backgrounds, who are less familiar with the capabilities of persons in the agricultural college, are less likely to encourage people within the firm to develop cooperative projects with university agricultural econo-

* Helpful comments by Patrick Luby and Denis Gaydon of Oscar Mayer & Co., John R. Schmidt, and Journal reviewers are gratefully acknowledged.

[1] Stanton discusses several additional factors affecting the relationship between business and the university in [25].

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[2] Only one-fifth of the larger firms (100–500 employees) in their study preferred to hire people with farm backgrounds.

[3] An exception exists with respect to recruiting sales executives and field specialists. FS Services believes that its regional sales managers and salesmen are better equipped for their jobs if they have agricultural backgrounds.

mists. This development also can be expected to have cumulative negative effects on the demand for graduates of agricultural economics training programs.

Developments that place university extension economists and agribusiness firms in competing roles affect the climate for cooperation. Extension economists and agribusiness firms such as FS Services now compete directly to supply farmers with management services and information concerning use of fertilizer, insecticides, herbicides, farm equipment, and other purchased inputs. Friction has developed as a result of this competition. University economists question whether the agribusiness firms supply objective information about purchased inputs they sell to farmers [25]. Some agribusiness firms, on the other hand, claim that the extension economist has an unfair competitive advantage because he can charge customers less than full cost for services [18]. If extension economists continue to supply a substantial number of educational services to commercial farmers, additional friction may arise over the question of charging less than the full cost for services.

Transitional Developments

Some heterogeneous developments that can be classified as transitional impair the climate for cooperation. One such development is the reduction in emphasis on studies of the firm and commercial agriculture that appears to be taking place in universities.[4] Another is the increase in amount of quantitative research. When, as apparently is often the case, agricultural economists neglect to publish nontechnical summaries of findings, the practical value of quantitative studies is reduced since many business people lack the time needed to determine whether they contain usable findings.[5] This problem may be less serious for the larger firms where the task of analyzing quantitative studies can be carried out by resident economists.

Changes in research focus and accompanying changes in courses taught by agricultural economists apparently have caused neglect of agribusiness. At least this can be concluded from recent criticisms by industry economists and officials: A. C. Hoffman, for example, claims that much of the current published agricultural economics research is of little interest to agribusiness or commercial agriculture [14, p. 454]. Shaffer [21] reports that officials of marketing firms complain that university and USDA research is not usable because it becomes available too late or is not directly relevant for decision-making. Hoffman [14], Coats [3], and Cox [6] suggest that current training received by many agricultural economists is too narrow to equip them for modern agribusiness jobs. Hoffman [14, p. 449] suggests that training is particularly deficient for economists promoted to administrative positions. Training deficiencies may make it difficult for agricultural economists to obtain agribusiness jobs and over the longer run may reduce the demand for them.

Transitional developments may be responsible for lower membership by agribusiness employees in AAEA, one of the vehicles that could be most effective for promoting university-agribusiness cooperation and interaction. Agribusiness employees comprise a relatively small and declining proportion of the economists in the Association (Table 1).[6] In 1961 about 11 percent of AAEA members were employed in agribusiness; by 1966 this had fallen to 8.15 percent. There was an absolute decline of 8.5 percent in AAEA members employed by agribusiness from 1961 to 1966. This decline is noteworthy since it occurred during a time of rapid expansion in aggregate AAEA membership (23.7 percent) and during

[4] See French [9] and Hitzhusen [13] for discussions of this point. They describe changes in fields of specialization of university and other agricultural economists that produce the reduction. Hitzhusen reports that the number of AAEA members specializing in (1) farm management and production economics, (2) agricultural prices, and (3) marketing changed by −10.2 percent, −16.8 percent and +.2 percent, respectively, from 1961 to 1966. The number of AAEA members specializing in (1) foreign trade and development; (2) land and water economics, conservation, and development; and (3) general economic theory increased by 244.4 percent, 63.8 percent and 47.5 percent, respectively, during the same period. The adjustments described by Hitzhusen probably occurred mainly within universities and government agencies, since the areas of specialization showing large increases are types of work that would be logically carried out within these organizations.

[5] This problem was pointed out to us by Denis Gaydon of Oscar Mayer & Co.

[6] For purposes of the analysis, members counted as agribusiness employees were those listed in the 1961 and 1966 AAEA directories as holding jobs with agricultural marketing and processing firms, agricultural input supply firms, farm management firms, private economic consulting firms, firms supplying operating and mortgage credit to farmers, agricultural trade associations, and training institutes that provide educational services and educational material to agribusiness firms.

Table 1. Agribusiness members of AAEA, by type of employer and position, 1961 and 1966

Employer and position	1961		1966		Percent change 1961–1966
	Number	Percent	Number	Percent	
Agribusiness Firm					
Economist[a]	127	35.77	129	39.69	1.57
Administrator or manager	126	35.49	99	30.46	−21.43
Management trainee	—	—	4	1.23	—
Salesmen and sales manager	5	1.41	7	2.15	40.00
Attorneys, buyers, engineers, other	22	6.20	16	4.92	−27.27
Unspecified[b]	15	4.23	13	4.00	−13.33
Trade association or institute					
Economist[a]	19	5.35	18	5.54	−5.26
Administrator or manager	34	9.58	34	10.46	.00
Fieldmen	2	.56	—	—	−100.00
Unspecified[b]	5	1.41	5	1.54	.00
Agribusiness totals	355	100.00	325	99.99	−8.45
Directory totals	3,223		3,986		23.67

[a] Includes economists, price analysts, economic statisticians, corporate planners, and economists with split appointments involving administrative and other responsibilities.
[b] Persons with agribusiness affiliations but no job title listed.
Sources: 1961 and 1966 AAEA directories [8, 11].

a prosperous business period when sizable numbers of employees were added to business payrolls. A large proportion of the decline can be accounted for by the reduced number of administrators and managers of agribusiness firms who were Association members (Table 1). The number of members who were economists in agribusiness firms, trade associations, and institutes remained almost the same.

The Association is comprised dominantly of members employed by universities and government agencies. According to Melichar [20, p. 904], about 83 percent of AAEA members held university or government positions in 1966. An Association that gears its activities primarily for those whose interests appear to be trending away from the firm and commercial agriculture might expect to experience difficulty in maintaining the number of agribusiness members. Recent efforts by AAEA to provide more programs and activities of specific interest to agribusiness may help to increase its agribusiness members. However, competition from business-oriented professional associations is likely to prevent any large agribusiness membership increase.

The several developments discussed appear to impair the basis and opportunity for cooperation. Large agribusiness firms need little assistance from university agricultural economists, and a poorer climate for cooperation with firms of all sizes seems to exist. Hence, job opportunities for the agricultural economist in agribusiness may be reduced. Certain of the developments also may impair the competitive viability of agribusiness firms. The competitive vigor of smaller companies in particular could be reduced by the lack of relevant, timely, and usable research studies relating to the firm. If there is a desire to maintain effective cooperation and obtain the benefits that might accrue from it, an increasing effort may be required to achieve this result.

Opportunities for Future Cooperation

Cooperation might be improved if university agricultural economists published applicable research findings on a more timely basis and in forms more readily usable by businessmen. Also, AAEA might do more to foster cooperation, if there is a consensus that this is needed. These and related measures have been discussed elsewhere [9, 14, 17].[7] The remainder of this article therefore focuses mainly on forms of cooperation that may be important to cultivate in the future, namely, cooperative effort by university agricultural economists to supply technical assistance to small and medium-size firms and development of improved agribusiness training programs. Substantial payoffs and a basis for cooperation exist in these areas despite current threats to cooperation.

[7] In view of some of the developments described it is possible of course that these areas may need additional attention in the future.

Table 2. Cost savings or increases in profits from use of recently developed operations research models[a]

Study	Type of model	Cost saving	Profit increase
Matthes [19]	Management information and control system for meat packing plants		2 percent of sales
Stafford and Snyder [24, p. 3]	Assembly model for feed manufacturers		$7.07 per ton
Haynes [12, p. 63]	Multi-period linear programming bank planning model		29 percent
Waterman and Gee [26]	Single-period linear programming bank planning model		3.7–13.6 percent
Lee and Snyder [16, p. 29]	Location-logistics model for feed manufacturers	8–10 percent[b]	
Snyder and French [23, p. 2]	Disassembly-assembly model for meat packers		10 percent

[a] Results reported from applications in case firms.
[b] Annual savings in investment expenditures for new facilities.

Assistance needed by agribusiness firms

In the future medium-size and small agribusiness firms may have incentives to develop cooperative working arrangements with university economists in order to obtain the technical assistance available to larger firms from internal research organizations and market sources. Agribusiness firms face what Smith characterizes [22, p. 429] as the challenge of integrating the formerly dominant experience-intuition factor with the new scientific management. Among other things this means that managers will need to develop improved financial management techniques and cost control methods and will have to employ the computer and operations research techniques in decision-making.

For smaller agribusiness firms the challenge may pose difficult problems, since their personnel may not possess the specialized skills required. These firms may require university help for incorporating operations research (OR) decision models which produce high payoffs but which may be difficult for smaller firms to obtain and implement. Recent studies (see Table 2) and user comments suggest that firms failing to adopt new operations research techniques may face a profit squeeze. The operations research models listed in Table 2 produced sizable cost savings (or profit increases) in different types of firms, some of them remarkable when viewed against low profit rates in some agribusiness industries. The Matthes model, for example, offers a possible profit increase of 2 percent of sales to firms in the meat-packing industry where profits currently average only about 1 percent of sales [1, 19]. According to reports from a few users in larger agribusiness firms, some operational models produce savings similar in size to those reported for the case applications. Nonadopting firms may find it difficult to compete with firms that obtain lower costs by using the models.

We do not claim that successful application of OR models will be easily achieved in all types of agribusiness firms. Problems admittedly exist which apparently have prevented some models developed by university agricultural economists from being applied by agribusiness firms. We questioned officials and economists of seven agribusiness firms (in addition to FS Services personnel) about their experiences with application of OR techniques. Responses suggest that when firms fail to adopt potentially useful models it is usually for one or more of the following reasons: The models are (1) too complex to be operationally efficient, (2) not of proven dependability, or (3) not sufficiently specific to the requirements of the firm; or (4) the electronic data processing equipment required for assembly of input data is not available. Given current monetary incentives for using OR models, we suspect that many of these difficulties will be overcome. Officials of two of the firms contacted report that they successfully overcame problems (1) and (2) by stripping away "frills" and by extensive refinement and testing of models. Problem (4) will become less important over time as firms acquire additional data processing equipment and increase their use of time-share computer systems.

Larger agribusiness firms should experience few problems in obtaining from private companies the needed computer hardware, com-

puter software, and any assistance required for adopting OR systems. Their production volume makes the use of an OR system particularly attractive, and they often employ personnel who understand its workings and advantages. This tends to make them lucrative accounts for private OR firms. On the other hand, in smaller firms whose employees are often less familiar with models, sellers of OR packages report that it is more difficult to sell the systems or to maintain user satisfaction. Smaller firms also have a lower ability to pay. Because of these factors commercial sellers of OR systems tend to concentrate their efforts on larger companies.[8]

Consequently profit-oriented private companies may not adequately serve all needs; some small and medium-size agribusiness firms may need university aid. Because of extension experience, expertise in OR and computer techniques, and affiliations with agribusiness, many university-based agricultural economists are well-equipped to assist smaller firms with OR models and related management techniques. Extension programs may be particularly suitable for providing the training in model use and management techniques required to make use of OR models feasible in smaller firms. Assistance in OR and related work of necessity would involve some firm specific work. Whether the agricultural economist will help the small and medium-size firms depends partly on his attitude and that of his institution toward firm specific work and the benefit that they believe will accrue from work with smaller firms.

Benefits from firm specific work

Firm specific work by university personnel is criticized because its public costs may exceed its public benefits and because of its possible regressive effects on income distribution [21, 25]. However, there are some payoffs for the public, the agricultural college, and the researchers from this work that critics may overlook. We shall discuss some of these payoffs, as well as some ways by which the university agricultural economist might lessen the impact of the firm specific work on income distribution and reduce public costs for the work.

University staff members would receive valuable experience from firm specific work with the agribusiness firms, experience that would provide the expertise required for constructing realistic subsector models,[9] institution building,[10] measuring the impact of vertical integration, and developing relevant agribusiness teaching programs. The experience gained would produce public benefits by contributing to improvement of research and teaching programs.

Firm specific work can help to promote the development of the economy of a state or region. OR work and feasibility studies for agricultural firms that are considering location within the state are types of activities that can contribute to economic development. These activities could promote development and produce public benefits by lowering costs,[11] increasing employment, and strengthening the competitive position of agribusiness firms in the state or region.

Equity considerations, as well as the possibility that the larger, self-sufficient agribusiness firms may not want or need much assistance, would suggest that work by the university agricultural economists might be concentrated with smaller firms. OR work which might be carried out by agricultural economists with smaller firms may warrant a reasonably high priority, since this work would increase the efficiency and competitive viability of the small and medium-size firms which in some areas employ substantial numbers of farm and nonfarm people and help to support local economies. Should smaller firms fail because of lack of technical assistance, this could increase concentration in agribusiness industries, which might on balance have some undesired consequences for public welfare.

It can be argued that until concentration in agribusiness industries becomes much higher failures of additional smaller agribusiness firms will improve the efficiency of resource use and increase total welfare.[12] This is a complex ques-

[8] For example, during recent discussions of OR problems at the University of Wisconsin, representatives of the computerized technology department of a large chemical company reported that their firm attempts to sell its linear programming feed formulation packages only to mills with annual production exceeding 50,000 tons. This type of sales policy is followed by a number of other sellers of OR systems.

[9] This point is discussed by Shaffer [21].

[10] By institution building we mean development of mechanisms such as the standby pool, the new voluntary milk supply control device described by Cook [5].

[11] The amount of public benefit from lower costs will depend partly on the extent to which the cost reductions are reflected in lower prices to consumers.

[12] This argument was made by a Journal reviewer.

Table 3. Recommended schedule of charges for firm specific work

University activity	Firms benefiting from activity	Appropriate university fee policy
Stage 1 Develop new OR model or related technique	Typically none immediately; potentially many	No charge
Stage 2 Adapt existing model or technique to first-case firm	Case firm, immediately; potentially beneficial to other firms	Charge case firm for portion of variable costs;[a] no "overhead" charge for personnel
Stage 3 Adapt existing model or technique to other firms	Recipient firm, immediately	Charge firms full cost including all variable costs and proportionate share of variable and overhead costs not recovered in stages 1 and 2

[a] Variable costs include expenses such as computer and travel costs.

tion which must remain unresolved until more empirical research is available on the subject. However, a recent dairy industry study [7] provides little support for the argument. That study simulated losses of business and financial failures of smaller dairy firms, which resulted in a simulated reduction in milk processing that averaged 28 percent in 31 market areas where milk plants are relatively small and a transfer of an equivalent quantity of processing to 14 areas where milk plants are large. For the market system the aggregate reduction in processing costs resulting from this reallocation of processing to the larger plants was only 2 cents per hundredweight [7, p. 23]. In industries with greater economies of size transfers of this type would produce larger savings, but in this case the cost savings were small compared to the possible adverse effects on competition.

We believe that university agricultural economists who assist individual firms should ensure that competing firms obtain access to the models and help in adapting them to their needs. This measure would avoid creating semi-permanent redistribution of income in favor of firms receiving assistance initially.

Universities might charge a fee for their services in order to reduce public costs of firm specific work and provide funds for program support. We suggest a schedule of charges (Table 3) based on the type of activity involved and the number of firms benefiting from the work. The charges range from zero for methodological studies (stage 1 activities) to full costs for adapting existing models to firms other than the first-case firm (stage 3 activities). Stage 1 activities as defined here are methodological studies in the strictest sense where involvement of firms typically is limited to supplying data for validating a model. Since the primary purposes of this type of activity are to advance general knowledge and to train graduate students, no charges would be assessed to the cooperating firm. The portion of the variable costs incurred by the university for activities in stage 2 that are charged to the firm should be decided on an individual project basis. If the model or technique involved is not fully perfected (stage 1 work remains to be done) and the risk of failure high, a large portion of the costs should be charged to development of new methodological techniques. Since stage 3 activities would be primarily service activities, firms should pay their full costs.

If these measures are adopted we believe that the payoffs from firm specific work may warrant a reasonable amount of OR and related work by university agricultural economists with small and medium-size agribusiness firms in particular. This work should produce public benefits, help to preserve the financial health of the small and medium-size firms, and generate support for the agricultural college. To obtain maximum benefits it will be necessary to select the proper delivery mechanism. Since much of the work may involve application of proven OR techniques (e.g., linear programming) rather than new techniques most suitable for graduate student thesis projects, the work in most cases probably can be best done under an extension program, especially when broader management training programs are involved.

Although most of the need for cooperative work involves smaller agribusiness firms, some concurrent opportunities for cooperative research with larger firms will likely exist. Large

expenditures of risk capital are required to conduct some studies and several parties may benefit if costs can be shared. FS Services currently is engaged in a cooperative study with university agricultural economists which involves application of Forrester's Industrial Dynamics to the firm's fertilizer distribution system. The company hopes to use the model as a planning guide. Experience at FS Services suggests that, properly conducted, studies of this type can produce useful tools for the firm and valuable training for graduate students involved. Such projects also permit exchange of ideas and keep universities in contact with developments in larger firms.

Training programs

Cooperation is needed also in developing improved agribusiness training programs. Comments of industry economists suggest that the scope of the training received by agricultural economists is too narrow. Moreover, it may be important for colleges to develop more suitable training programs since employment of agricultural economists in government, university, and extension positions may be nearing saturation levels [14, p. 451].

Joint effort might be profitably applied to develop an improved M.S. program for agribusiness. The job market in business for agricultural economists trained at the M.S. level is now served primarily by the M.B.A. (Master of Business Administration). For example, during the 1969–1970 academic year, firms in the food and beverage industry alone offered jobs to about 140 new M.B.A.'s from U. S. business schools [4]. The number of M.B.A.'s offered jobs in that one year was slightly more than the total number of agricultural economists (137) in agribusiness jobs who were listed in the 1966 AAEA directory with the M.S. degree as their highest degree [11]. Thus, a moderately large market that might be served to a greater extent by agricultural economists exists in agribusiness for personnel with graduate training.

It would be neither feasible nor desirable to duplicate M.B.A. programs in the agricultural college, but portions of the M.B.A. program might be adopted. At FS Services and another agribusiness firm known to the authors, both M.B.A.'s and agricultural economists with the M.S. degree conduct economic analysis work; and in each firm the job performances of both groups is similar, with a few exceptions. The agricultural economists usually demonstrated a better knowledge of marginal concepts and the research procedures used in longer-term research, the latter advantage apparently derived from work on the M.S. thesis. The M.B.A.'s, on the other hand, typically displayed more knowledge of accounting and financial management techniques. The performance comparison suggests that an M.S. program which included strengths of both programs might be obtained by upgrading the M.S. thesis and adding courses in financial control and marketing management. The present level of training in economic theory and statistics in most agricultural economics M.S. programs should be maintained, if possible, so that any M.S. student who desired to go on for the Ph.D. degree could do so without deficiencies. These changes would produce the broader training for agricultural economists that industry economists suggested was needed. The training package should be desirable for students seeking agribusiness jobs in which competence in economic analysis is important, but accounting and related skills are also required. Since our performance comparison was based on a small sample, industry economists might be consulted for additional advice when curriculum revision is considered.

Summary and Implications

Significant payoffs consisting of public benefits, increased employment opportunities for agricultural economists, and healthier small and medium-size firms might accompany efforts to improve and expand cooperation between university agricultural economists and agribusiness. We have implied throughout the paper that it is appropriate for the agricultural economics department to work with agribusiness firms and train students for jobs in agribusiness. One may of course place a low priority on this work, but the possible consequences of doing so should be recognized. As we see it, university business schools probably will inherit much of the agribusiness work neglected by university agricultural economists. A comment by Judge [15, p. 1715] describes the business school's potential for research: ". . . the faculties of several business schools are doing some of the best theoretical and applied quantitative economic research and their role probably will become more important in the

future." Grubel [10] reports that business schools generally are upgrading their course programs, which will make it more difficult for agricultural economists to compete for agribusiness jobs. If agricultural economics is to remain viable, it may not be good strategy for it to abandon lightly or by default work that it has the potential to do well.

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Optimal Allocation of Generic Advertising Budgets*

EDWARD L. MCCLELLAND, LEO POLOPOLUS, AND LESTER H. MYERS

A model is developed for allocating advertising budgets among multiple consumer products marketed in several regions so that total consumer expenditures net of advertising costs are maximized. The model pertains specifically to unbranded commodity advertising where the budget is dependent upon uncontrolled industry production. Time series-based empirical estimates of consumer sales response to advertising expenditures are utilized as input data in a quadratic programming algorithm. Consumer expenditures under optimum and actual allocations were compared for selected historical budgets of the Florida Department of Citrus to obtain a measure of possible gain from more efficient allocation of advertising funds.

WHILE agricultural commodity organizations periodically invest in various types of promotional programs to expand demand, they generally do not have reliable knowledge of the national sales response to different levels of promotional dollars. Rarer still is information regarding the sales response to promotional inputs within individual marketing territories or regions. And while certain generic commodity advertisers may have considerable investments in various indirect measures or indicators of sales response such as product awareness, ad recall, and slogan recall, the relationship between these indicators and actual consumer purchase response is dubious. Given this state of imperfect knowledge, directors and managers of commodity organizations must allocate scarce advertising dollars over geographic markets by intuitive and ad hoc methods. A further complication is the frequent involvement with several commodities or at least with several product forms of a given commodity.

This paper attempts to develop an economic model for the allocation of advertising budgets by commodity organizations marketing multiple products in several geographic markets. It is assumed that an effective supply control mechanism is lacking for the commodities and products involved and that the commodity organization's products compete with each other within regions but have no competition from products produced by other firms. Regional time series, as opposed to experimental data, provide the basis for the measurement of consumer purchase response to advertising expenditures. Nerlove and Waugh [10] have studied the problem of commodity advertising without effective supply control; Nordin [11], Wellman [16], and Zentler and Ryde [17] have published various aspects of geographical advertising allocations of firms; Borden [2, 3] was the pioneer in the field of empirical advertising. However, no previous work deals with the combination of elements confronted here: industry-wide unbranded advertising, fixed or given advertising budgets, multiple marketing regions, a large number of producers unconstrained by effective supply control techniques, and the use of regional time series data to estimate consumer purchase response to advertising expenditures.

Advertising Response

The underlying hypothesis of this paper is that consumer sales response to advertising expenditures is quite different among individual commodities and over the several geographical regions. The particular form of the response function may be *sigmoidal*, as argued by Zentler and Ryde [17], or *parabolic*, as depicted in Figure 1. The response curves in Figure 1 illustrate the case of consumer sales of commodity i in region j increasing at a decreasing rate to a maximum level and then decreasing absolutely as successive advertising dollars are applied.[1] It is assumed that the advertising response curve, BC, intersects the vertical axis at some point greater than zero, say B. The intercept value at point B is in-

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[1] While the theoretical consumer sales response curve reaches a maximum, empirical observations are expected to be in the range to the left of the maximum point, i.e., where the marginal response to advertising is positive.

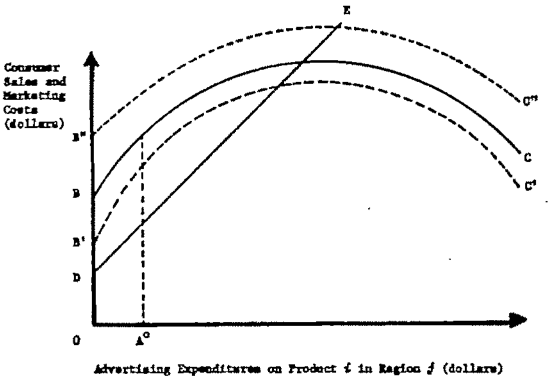

Figure 1. **Consumer sales response and net returns from commodity advertising expenditures in one product-region**

terpreted as the level of monthly dollar sales of q_{ij} assuming that no advertising for q_{ij} occurred, where q_{ij} is defined as the quantity of the ith product sold in the jth region.[2]

The advertising response curve, BC, may be positioned by either competitive or complementary advertising of related products produced by the commodity organization. A given level of advertising for product i is competitive if, for example, it shifts the response curve of product $k(k \neq i)$ downward and to the right (say from BC to $B'C'$ in Figure 1). On the other hand, the promotion of product i is complementary to the sales of product k if it shifts the response curve of product k upward and to the left (say from BC to $B''C''$). The shift to $B''C''$ is the so-called "umbrella effect" whereby the promotion of one product calls the consumer's attention to another similar product, thus stimulating sales for the similar product.

Of course many other factors tend to affect the positioning of a given advertising response curve over time. Two very important ones are population and personal income levels. Since both of these variables have been increasing at a relatively steady rate over time, empirical researchers may choose to use a "time" variable to reflect population and income changes, as well as other unmeasured variables whose values change uniformly over time.

For purposes of this study marketing costs are those expenditures incurred for generic advertising and promotion. Curve DE in Figure 1 illustrates the situation when generic advertising costs are considered as the only independent variable and all other firm production and marketing costs are assumed fixed. Segment OD represents fixed production and other marketing costs, i.e., all costs other than generic advertising costs. Consumer expenditures net of advertising costs are maximized at that level of advertising expenditures where the slopes of the cost curve and the response curve are equal. Thus for response curve BC, an advertising expenditure of $A°$ is optimum.

Advertising Decision Criterion

From an economic viewpoint equating the marginal consumer sales response to the marginal cost of advertising should be the decision criterion for allocating a given advertising budget.[3] The marginal sales response curve is negatively sloped, owing to the shape of the total consumer sales response curve in Figure 1. The marginal cost of advertising is assumed to be constant over all advertising levels. Given the total consumer sales response curve BC in Figure 1, the optimum decision in a simple one-commodity, one-region case is to advertise at the $A°$ level as shown in Figure 2.

Now if the commodity organization introduces another product into the region, the effects of competitive and complementary advertising within the region may be illustrated using the following interrelationships: Let

(1) $R_{1t} = a_1 + b_{11}A_{t1}, + b_{12}A_{2t} - c_1A_{1t}^2$

(2) $R_{2t} = a_2 + b_{21}A_{1t}, + , b_{22}A_{2t} - c_2A_{2t}^2$

where

R_{1t} and R_{2t} represent the total consumer dollar sales for products 1 and 2 respectively during time period t.

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[2] It is difficult to conceive of a response curve passing through the origin. Simon [13] suggests that such a case might be possible for mail-order firms handling monkeys and records.

[3] Given the specific case of the Florida citrus industry, it might be argued that because the grower is paying the advertising costs via an excise tax on each box of fruit marketed the net returns to the grower should be maximized. Since the advertising response occurs at the consumer level, this would involve deriving the grove price from the retail price using the appropriate margin relationship. These margin relationships are not currently known although research in this area is now underway. Also, there are a number of cases in which the optimum solution remains the same regardless of whether the optimization occurs at the consumer or grower level. These situations occur when: (1) the industry controls the total expenditures allocated; and/or (2) there is no interdependence of advertising effect between products within a market; and/or (3) the margins are constant in an absolute sense.

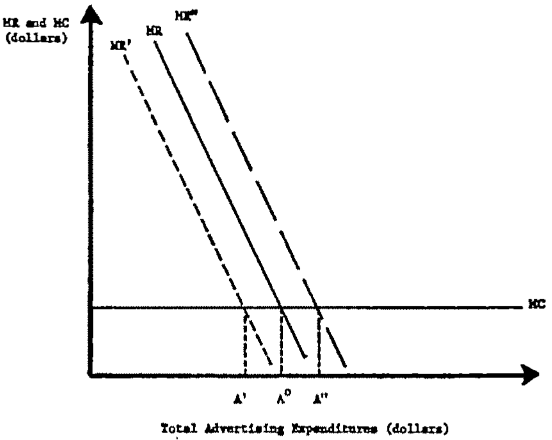

Figure 2. **Marginal consumer sales response (MR) and marginal cost (MC) of advertising in one product-region**

A_{1t} and A_{2t} represent total generic advertising expenditures on products 1 and 2 respectively during time period t.

a's, b's and c's represent advertising response parameters.

Then total consumer sales within the region during period t equals R_{1t} plus R_{2t} and the marginal responses to advertising expenditures are as follows:

$$MR_{1t} = (b_{11} + b_{21}) - 2c_1A_{1t} \tag{3}$$

$$MR_{2t} = (b_{22} + b_{12}) - 2c_2A_{2t} \tag{4}$$

where

MR_{1t} and MR_{2t} are the marginal dollar sales for products 1 and 2 due to changes in advertising expenditures on products 1 and 2, respectively, during period t.

The nature of complementary and competitive advertising response is as follows: Parameter b_{21} represents the marginal effect of advertising expenditures for product 1 on the consumer sales of product 2. If b_{21} is negative the marginal response curve for product 1 is shifted downward and to the left, say from MR to MR' in Figure 2. Thus the advertising of product 2 is competitive to the sales of product 1 and the optimal advertising expenditures for product 1 would decrease from $A°$ to A' in Figure 2. If b_{21} is positive, the marginal sales response function for product 1 is shifted upward and to the right, say from MR to MR'' in Figure 2. The advertisement of product 2 is complementary to the sales of product 1 and the optimal advertising expenditures for product 1 increases from A' to A'' in Figure 2.

The difference between intrafirm and interfirm competitive product advertising is clear. Given the assumption that both products are sold by the same firm, it is to the firm's advantage to limit advertising expenditures on those products for which such expenditures are competitive to sales and to increase advertising outlays on those products for which such expenditures are complementary to sales. One would of course expect just the opposite recommendations for two products sold by competing firms.

When dealing simultaneously with multiple commodities or products and multiple marketing regions it is convenient to algebraically subtract the constant marginal advertising cost from the marginal sales response, obtaining a net marginal sales response function for each product-region. In the absence of a budget constraint, the decision rule involves equating all of the net marginal response functions to zero. The total optimum advertising expenditure is the summation of the individual product-region expenditures [see 8, pp. 17 to 21].

Three different theoretical solutions are possible in allocating a fixed advertising budget. First, if the available budget is less than the optimum budget, the net marginal response in all product-regions entering the solution will be positive. In this case the industry would benefit from a larger advertising budget. Second, if the available budget is greater than the optimum budget, the net marginal response in all product-regions entering the solution will be negative, indicating that the industry is spending too much for advertising and would benefit by decreasing its budget. Third, the available budget could coincide with the optimum budget, in which case the net marginal responses would be zero in all product-regions.

Two conditions are necessary before the above decision rule for commodity advertising can be regarded as operable. First, the advertising markets must be spatially segregated. While it is recognized that some interregional advertising response occurs, it is assumed that these interregional effects are nullified and that it is possible to treat regions as independent with respect to advertising effects. Second, for given levels of advertising, the net marginal

advertising response must be different in at least several of the product-regions so that the allocation model can discriminate among them. If all net marginal response functions were identical, the solution would simply be to divide the budget equally among all product-regions.

The Model and Method of Analysis

It is assumed that the total consumer sales response function for product i in region j is a quadratic function of the advertising expenditures on product i in region j. The intraregional cross-product effects of advertising are accounted for by including the advertising expenditures for each of the citrus products within the region as independent variables.[4] Time is included as a dummy variable to represent the effects of changes in population, income, and unidentified forces on product sales.[5] Use of total consumer sales as the dependent variable precludes the identification of price effects on the demand for various citrus products. The quadratic programming algorithm allows for optimization with respect to the allocation of only one variable for each product-market, e.g., advertising expenditures in this case. Thus, even if demand were to be expressed as a function of price and advertising expenditures for each product-market, prices would need to be fixed at some predetermined level prior to maximization.[6]

A generalized consumer sales response equation is expressed as follows:

$$R_{ijk} = a_{ij} + \sum_{l=1}^{g} b_{ilj} A_{lj(k-\alpha)} - c_{ij} A^2_{ij(k-\alpha)} + d_{ij} T_k + \mu_{ijk} \tag{5}$$

where

R_{ijk} = total consumer sales of the ith product in the jth region during month k, in dollars.

$A_{ij(k-\alpha)}$ = total advertising expenditures for the ith product in the jth region during month $(k-\alpha)$, $\alpha \geq 0$, in dollars.

T_k = a time variable measured by numbering the months consecutively starting with July, 1960 = 1.

a_{ij}, b_{ilj}, c_{ij} and d_{ij} are unknown parameters.

μ_{ijk} = random error term with

$$E[\mu_{ijk}] = 0$$

$$E[\mu_{ijk}, \mu_{ijk}] = \begin{cases} \sigma_{ij}^2 & \text{for } k = t \\ 0 & \text{for } k \neq t \end{cases}$$

g = the number of citrus products (i, $l = 1, \cdots, g$)

m = the number of regions ($j = 1, \cdots, m$)

n = the number of monthly observations ($k = 1, \cdots, n$)

Since advertising expenditures are controlled by the commodity organizations, they are independent variables with respect to consumer dollar sales of the products advertised. Hence, single-equation least squares techniques are appropriate for estimating the a_{ij}, b_{ilj}, c_{ij}, and d_{ij} parameters.

Allocation of a given advertising budget is the next phase. The objective is to allocate the budget so that total consumer dollar sales, net of advertising expenditures, are maximized over all regions and products. In general terms the objective is to maximize

$$\sum_{j=1}^{m} \sum_{i=1}^{g} (\hat{R}_{ij} - A_{ij}) \tag{6}$$

subject to

$$\sum_{j=1}^{m} \sum_{i=1}^{g} A_{ij} \leq B$$

where

$\hat{R}_{ij}$ represent the estimated equations of R_{ijk} (equation 5). Since these equations are assumed to hold for all months, the k subscript is dropped.

[4] "Cross product effects of advertising" refers to the impact of substitute and complementary product advertising upon the consumer expenditures of a given product.

[5] Ideally one would like to include each of the measurable variables, as well as a time variable to account for the unmeasurable forces, as an independent variable in the analysis, but problems of multicollinearity preclude this. An alternative is to include income only. This was done in a study by Myers [9] and the results suggested high (1.5 for FCOJ) income elasticities. Undoubtedly some of the effect attributed to income was due to other factors affecting demand. Because of these problems it was decided to include time as a "representative" variable and not to make an attempt to also separate out the effects on sales from increases in consumer incomes.

[6] Considerable research has been done regarding the estimation of price elasticities of demand for various Florida citrus products. See Hall [5] and McCelland [7] for regional estimates; Myers [9] for U. S. retail level estimates and cross-elasticities between citrus juices and synthetics; and Weisenborn [15] for estimates at the FOB or wholesale level for the foodstore, institutional, and export sectors.

A_{ij} is as previously defined and B is the advertising budget.

The above allocation problem conforms to the traditional quadratic programming problem. The reader is referred to Boot [1], Kuhn and Tucker [6], and Chung [4] for the specification requirements of general quadratic programming problems and to McClelland [7, 8] for the specification details when applied to generic advertising allocation problems.

Empirical Results

Allocations of commodity advertising budgets over several geographic markets and multiple products were made for the Florida Department of Citrus. The Florida Department of Citrus, known as the Florida Citrus Commission prior to 1969, is responsible for expanding the demand for both fresh and processed citrus products produced by Florida growers. Promotional and other operating funds are generated from excise taxes levied on citrus fruit when it first enters the primary channels of trade. Tax rates are fixed for a given crop year but may be changed through state legislative action between succeeding years.

Six product forms and nine geographical marketing areas are included in the allocation model. The products are canned single-strength grapefruit juice, canned single-strength orange juice, frozen concentrated orange juice, chilled orange juice, fresh oranges, and fresh grapefruit. Regional markets are the New England, Pacific, Mountain, West North Central, West South Central, East North Central, East South Central, Middle Atlantic, and South Atlantic regions, whose geographical boundaries are identical with those defined by the Bureau of the Census.

Monthly consumer expenditure data for July 1960 through June 1967 for the six citrus products were obtained from the Market Research Corporation of America on a regional basis, and regional advertising expenditures were derived from Florida Department of Citrus accounting invoices. Omitted from the advertising expenditure data series were by-product advertising, medical advertising, trade promotions, and other promotions not directed to the consumer retail market. The price index of food purchased for home consumption was used to adjust all monetary units to the June 1967 price level [14].

Total advertising response equations were estimated using the regression model previously specified. Of the 54 product-region equations, 35 fulfilled the necessary and sufficient conditions for application of the quadratic programming model and also explain a statistically significant, at the .05 level, amount of the variation in consumer expenditures.[7] Product-region advertising expenditures were deducted from each equation to yield total sales response functions net of advertising costs.[8]

Both unconstrained and constrained optimal allocations of generic advertising budgets were solved to maximize total consumer sales net of advertising expenditures. Separate solutions were necessary for the processed and fresh products because consumer sales data for the processed products were available on a twelve-month annual basis whereas sales data for fresh products are available only seven months during the year.

Advertising allocations were obtained from the quadratic programming routine for a variety of situations. Of considerable interest was the aggregate and optimal advertising budget that would be necessary for all six citrus products when no budget constraint was imposed, i.e., when marginal sales response to advertising is equal to the marginal cost of advertising in all product-regions. From this optimum budget level various budget constraints were imposed in order to determine how the advertising allocations differed regionally and by product category as the budget was reduced in size. Several solutions utilized actual Department of Citrus budgets for selected years to compare actual allocations with constrained optimum allocations. Finally, an allocation was calculated by combining the processed products with the fresh products, subject to a seven-month budget constraint.

Because of the extensive nature of the empirical results only a few highlights are presented here. Table 1 contains a summary of the advertising allocation results for varying levels of the annual aggregate budget when fresh and

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[7] If only the necessary and sufficient conditions for quadratic programming are used (and less than the .05 level of significance is required for individual response functions), there would be 45 of the 54 possible product-regions available for analysis. The optimum advertising budget allocations for these 45 product-regions are presented in McClelland [7].

[8] The estimated coefficients for the response curves, along with the associated R^2's, Durbin-Watson statistics and t ratios are available by writing to the Department of Agricultural Economics, University of Florida, Gainesville, Florida 32601.

Table 1. Total monthly and seasonal consumer sales[a] and marginal sales responses, net of advertising expenditures, for 35 product-regions under varying levels of processed and fresh citrus annual advertising budgets

Annual advertising budget	Total monthly consumer sales[b]	Total seasonal consumer sales[b]	Marginal sales response, net of advertising expenditures
	million dollars		*dollars*
	Processed products		
0	19.50	234.00	—
1.0	20.55	246.60	6.700
2.0	21.00	252.00	3.995
3.0	21.23	254.76	1.978
4.0	21.33	255.96	.498
4.36	21.41	256.92	0
	Fresh products		
0	9.80	68.60	—
0.5	12.98	90.86	34.929
1.0	14.98	104.86	23.254
1.5	16.19	113.33	14.949
2.0	16.76	117.32	7.089
2.45	16.70	116.90	0

[a] Total consumer sales are computed using an "average" value for the time variable; thus seasonal sales are simply monthly sales multiplied by the appropriate number of months in the marketing season.
[b] Monthly and seasonal consumer sales are totals for all product-regions.

processed products are treated separately. When the advertising budgets are not constrained the optimal annual advertising budgets for the processed and fresh citrus products are $4.36 mi lion and $2.45 million respectively. Allocatiolns of these two budgets resulted in monthly total consumer sales in the 35 product-regions of $21.4 million for processed products and $16.7 million for fresh oranges and fresh grapefruit. The marginal sales response, net of advertising expenditures, is zero in all product-regions due to the exclusion of a budget constraint. Estimates of the level of consumer sales when there is no advertising are also provided in Table 1. As the annual advertising budgets are increased from zero level, total consumer sales increase but marginal net sales responses decrease.

Of the four processed products, canned single-strength orange juice received the largest portions of the advertising budgets, with particularly large allocations in the South Atlantic and West South Central regions. Chilled orange juice advertising allocations were greatest in the Middle Atlantic region, especially at the large budget levels. A relatively large share of the advertising expenditures for canned single-strength grapefruit juice were concentrated in the eastern regions of the United States. Frozen concentrated orange juice, which utilizes the largest portion of the Florida orange crop and has historically received large promotional inputs, was allocated relatively smaller portions of the budgets in the model. This somewhat surprising result can be partially explained by an inability to empirically explain statistically significant, at the .05 level, amounts of the total consumer sales of the product in several of the major marketing regions. The relatively small optimal allocation going to frozen concentrated orange juice may also be due to the importance of price, weather, merchandising, and other factors, relative to consumer advertising, as independent variables in the explanation of consumer frozen concentrated orange juice expenditures. Also, the response to changes in consumer incomes may not be adequately accounted for via the use of a time variable.

Fresh fruit budgets were allocated primarily to fresh grapefruit. On a geographical basis, fresh grapefruit and fresh oranges in the eastern regions of the United States received the largest allocations. These regions have historically provided the bulk of Florida's retail market for fresh fruit.

Comparison of actual advertising allocations of the Florida Department of Citrus with the theoretically optimum allocations as determined by the quadratic programming analyses, indicates that consumer dollar sales would have been substantially larger if the optimum allocations had been employed. Actual and optimum advertising allocations are compared in Table 2 for three situations: an average budget of the 1960–1967 period, the historically large budget of 1966–1967, and the 1965–1966 budget. The 1966–1967 budget was the largest commodity advertising budget in the history of the Florida citrus industry, primarily because of the record harvest of citrus fruit in that season. In terms of the three situations analyzed, the 1966–1967 advertising budget was misallocated the most, if misallocation is judged as the difference between actual and theoretical total net consumer expenditures. Total consumer sales in the 35 product-regions theoretically

Table 2. Total monthly and seasonal consumer sales and marginal responses, net of advertising expenditures: actual and theoretical budget allocations

Crop season	Allocation procedure	Annual advertising budget	Total monthly consumer sales net of advertising expenditures	Total seasonal consumer sales net of advertising expenditures
		million dollars		
	Processed products			
1966–1967	Actual	3.49	20.01	240.12
	Theoretical	3.49	21.30	255.60
Average of seven seasons, 1960–1967	Actual	1.73	19.93	239.16
	Theoretical	1.73	20.89	250.68
1965–1966	Actual	1.33	19.86	238.32
	Theoretical	1.33	20.72	248.64
	Fresh products			
1966–1967	Actual	.71	13.17	92.19
	Theoretical	.71	13.97	97.79
Average of seven seasons, 1960–1967	Actual	.56	12.85	89.95
	Theoretical	.56	13.29	93.03
1965–1966	Actual	.62	13.03	91.21
	Theoretical	.62	13.58	95.06

could have generated an additional 21 million dollars if the optimum allocation had been applied in the 1966–1967 season.

When processed product and fresh fruit budgets were combined in one allocation model, fresh fruits were allocated greater proportions of the advertising budgets than in the independent allocations, partly because of the structure of the total consumer sales functions. Cross-product advertising terms for the two fresh fruit products were generally positive, while cross-product terms for the processed products were generally negative. Hence, the "umbrella effect" appeared to have a greater effect on the fresh fruit markets.

Conclusions and Research Complexities

Application of a decision criterion in the allocation of commodity advertising budgets, as opposed to intuition, theoretically increases the level of consumer dollar sales of the advertised products. More importantly, the quadratic programming formulation provides a multiple-product organization with guidelines regarding the optimum advertising expenditures in specific geographic markets under alternative budget constraints. Basic knowledge is acquired about response of consumer sales to various levels of advertising, as well as a better understanding of the competitive and complementary advertising effects.

This is not to say that the empirical procedure is free of estimation problems.[9] The assumptions of spatially segregated markets and significantly different slopes of the marginal net response functions may not be upheld in particular product-regions. Estimation of the advertising response function may be frustrating or impossible from available time series data. This latter difficulty may not necessarily be due to any peculiar ineptitude of the researcher; rather, a consumer sales advertising relationship may be diminutive because of the overriding influence of numerous price variables, weather factors, and merchandising practices. A special problem arises from the common merchandising practice to combine a price decrease with a promotion program, e.g., the cents-off coupon and multi-unit price specials.

There are, of course, limitations and possible biases with the consumer and advertising expenditure data. In the empirical example of the Florida citrus industry, consumer sales data for the 54 product-region combinations were obtained from a national expansion of a sample of 7,500 panel families of the Market Research Corporation of America. While the advertising expenditures were developed from the originating source (Florida Department of Citrus), it was sometimes difficult to regionally allocate certain advertising messages distributed nationally in magazines and on television. Also vexing (but fortunately of relatively small dollar value) was the problem of how to handle "gross generic" advertisements that simply urged consumers to buy Florida citrus in any product form—fresh, canned, chilled, or concentrate.

While commodity or unbranded advertising is the focus of this paper, there is presumably some interrelationship between commodity and brand advertising as it affects the level of consumer expenditures. Brand advertising expenditures of the products included in the empirical example were omitted because of lack

[9] In the context of cross-sectional and time series single-equation models, as well as simultaneous equation econometric models, Quandt [12] attributes the possible failure to measure advertising effectiveness to three general causes: (a) contamination of the data, (b) unfulfillment of preconditions for the applicability of the statistical model, and (c) a defective underlying economic model.

of data. Also unavailable on a regional basis were brand advertising data for close substitutes, such as imitation orange drinks. While no doubt the results would have been strengthened with the inclusion of branded product advertising, it is true that national or regional brand advertising is virtually inconsequential for the six natural products under study (with the possible exception of one packer label). Also, only one large food manufacturer heavily advertises a line of synthetic citrus drinks. Finally, prior research suggests that powdered synthetic orange drinks do not compete significantly with the orange juices, and frozen orange synthetic is only a weak substitute for FCOJ and canned orange juice [9, p. 20].

The attempts to define the effect of advertising lags upon consumer expenditures were not completely satisfactory. While various models of lagged response were attempted in the preliminary research stages, no single model was generally applicable for a particular product across all regions or for all products within a given region. Additional research is necessary to suggest a general framework for advertising lags for a set of similar products marketed in several independent markets.

Despite the various limitations and research complexities, a useful generic advertising model has been identified. The empirical results demonstrate potential benefits to commodity organizations from estimating advertising response functions, applying the marginal decision rule, and optimally allocating a fixed annual advertising budget over several products and geographic markets.

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Differences in Consumption Patterns of Farm and Nonfarm Households in the United States

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This article examines the hypothesis of differential consumption patterns in farm and nonfarm households, using the 1960–1961 BLS and USDA survey of consumer expenditure data. Comparisons were based on Engel curves for major consumer categories of consumption. Parameters of Engel curves were derived by OLS and TSLS. The results of the comparisons clearly indicate that consumption patterns differ significantly in the two households for the United States as a whole, although the differences are not as marked on a regional basis. The level and stability of income are not important factors contributing to the differences.

FARM and nonfarm households differ in many aspects: income stability, distribution, and level; home ownership and location; expenditure on food; power availability; and many other factors. Because of these differences it has often been asserted that there are marked differences in their consumption patterns. However, so far there have been no published empirical studies that test this hypothesis.

The purpose of this paper is to present empirical evidence in support of the assertion that farm and nonfarm households do have different consumption patterns. Data from the 1960–1961 Bureau of Labor Statistics (BLS) and U. S. Department of Agriculture (USDA) survey of consumer expenditures and income [17] are used to compare consumption patterns based on Engel curves fitted to income, expenditure, and family size of the two groups of households.

There are at least three reasons for conducting such an investigation. First, according to Friedman's permanent income hypothesis [5], the difference in measured income elasticities of nonfarm and farm households is largely due to the stability of income, since income is more stable for nonfarm than for farm households. If the effects of transitory components of income are removed, the difference in permanent income elasticities of the two households will be reduced; the remaining difference then reflects only differences in tastes and preferences. It is of interest to find out whether differences in expenditure patterns of the two groups are still significant when the effects of transitory components of income are eliminated.

Second, we are aware of no published research on consumption patterns of U. S. farm households nor of any comparison of farm-nonfarm households' consumption patterns. The quantitative information about whether differences in consumption patterns still persist even after certain important economic and demographic variables have been controlled is of interest not only in itself; the magnitude of any possible differences may also be useful for public policy. Finally, if consumer expenditure patterns are significantly different, this knowledge may help sellers plan different marketing strategies, although our study is confined to major categories of consumption.

Data

The BLS-USDA survey covered 17,283 families; usable schedules were tabulated for 1,967 farm families and 11,761 nonfarm families. Data for nonfarm families are available separately for urban and rural areas; and separate schedules for farm, rural nonfarm, and urban families were tabulated for four regions: Northeast, Northcentral, South, and West.

The BLS-USDA tabulations were classified by a number of family characteristics but not cross-classified by more than two characteristics. The data cross-classified by disposable income (Y) and family size (N) were used in this study to estimate the Engel curve parameters.[1] In these data N was classified into six

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[1] As explained in the next section, family income and family composition are the two most important determinants in the analysis of family budgets. Family size or family type has been used usually as a proxy for family composition. The BLS-USDA survey also cross-classified the data by Y and family type, the latter being classified in seven types on the basis of the relationship of family members and the age of the children of the head of the family. However, information on the "value of home-produced food" is not included in these data; and since the value of home-produced food was nearly 60 percent of cash food expenditure for farm households, information on income,

sizes, namely, one-person households through households of six persons or more. For households of each family size Y was classified into 10 classes, from under \$1,000 to \$15,000 and over, in \$1,000 or \$1,500 intervals. One-person households were excluded from the computations. The lower open-ended Y class was also excluded since incomes in this class are likely to be less accurately reported and possess more transitory elements than higher incomes [3]. Moreover, negative income observations preclude the use of a logarithmic transformation on the data.

Engel curves for the following major categories of consumption are estimated for comparison:

- X_1 total food
- X_2 food prepared at home
- X_3 food away from home
- X_4 tobacco and alcoholic beverages
- X_5 total housing
- X_6 shelter
- X_7 fuel, light, refrigeration, and water
- X_8 household operations
- X_9 house furnishings and equipment
- X_{10} clothing, clothing materials, and services
- X_{11} personal and medical cares
- X_{12} recreation, reading, and education
- X_{13} transportation
- X_{14} other expenditures

In the BLS-USDA tabulations the value of home-produced food was listed separately. We included it in Y, C (total consumption expenditures), X_1, and X_2. In order to give the reader an idea of the relative income and expenditures of the three groups of households in the various regions, Table 1 contains the weighted averages of Y, C, and the X's for those families included in the computations.[2] The number of families is also given. Note that the values in the table are different from those in the basic BLS-USDA tabulations because of inclusion of the value of home-produced food and the exclusion of one-person households and the open-ended lower income class.

Equations and Comparison Procedure

The basic equations

In deriving Engel curves, C is often used as a regressor. However, Summers [16] has shown that the ordinary least squares (OLS) estimates of the Engel curve parameters will be biased and inconsistent if C is used as an explanatory variable. The reason is that the X's are jointly determined with C; that is, there is "feedback" between the X's and C.

Because of the absence of income data, many early budget studies used C as a proxy for Y. Even when income data are available, Houthakker and Taylor [9] continue to use C rather than Y as the regressor. They argue that C is a better measure of "true" income because in the short run consumers have more control over expenditure than over income. In his review of [9], Perry [13] rejects this reason for using C and argues convincingly for the use of income as the more economically relevant variable. Crockett and Friend [3] also favor the use of income because certain types of consumption may be mainly competitive with saving rather than with other consumption categories. According to the permanent income hypothesis (PIH),[3] however, OLS yields biased and inconsistent estimates of the true parameters when Y instead of permanent income (Y_p) is used.

On the basis of Summers' analysis, Liviatan [12] has developed a method to obtain consistent estimates of the parameters of Engel curves when C is used as a regressor. To illustrate Liviatan's method and to derive the equa-

total consumption, and food contained large measurement errors. Hence this study reports only the results estimated from the data cross-classified by Y and N, which have information on the value of home-produced food. The results, however, are not much different from those based on the data cross-classified by Y and family type. Owing to the large number of households the differential effects of variations in composition are likely to average out in the data cross-classified by Y and N.

[2] The weighted averages were derived with the number of households in each income class serving as a weight. BLS and USDA also used this method of calculation.

[3] As is well known, in the PIH both measured income and consumption are divided into permanent and transitory components (called by Friedman permanent and transitory income and consumption), and permanent consumption is hypothesized to be a constant proportion of permanent income. In addition, the PIH assumes that transitory consumption and income are uncorrelated with one another and with the corresponding permanent components and that the mean transitory components of consumption and income are both zero. In applying the PIH (in terms of total consumption) to individual categories of consumption, it is also assumed that the transitory component of individual expenditures is both uncorrelated with permanent and transitory components of income and averages zero for a group of households as a whole for any income class. The zero mean assumption of the transitory components of total expenditure and individual expenditures is questionable, although it is likely justified with cross-section data.

Table 1. Number of families and average income and expenditures

Regions[a]	Number of families	Variables[b]															
		Y	C	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
Urban																	
NE	2,232	6,964	6,441	1,660	1,351	306	242	1,878	888	299	368	322	701	585	391	833	150
NC	2,280	6,586	5,845	1,403	1,147	255	202	1,699	790	279	315	310	607	543	363	904	122
S	1,916	5,699	5,265	1,230	980	250	155	1,526	642	241	345	295	564	526	316	838	111
W	1,449	7,009	6,442	1,532	1,217	315	204	1,823	859	249	376	339	633	537	515	1,045	153
Rural, nonfarm																	
NE	368	6,078	5,688	1,384	1,169	213	201	1,635	678	376	279	299	525	492	351	972	118
NC	531	5,253	4,677	1,198	1,002	193	140	1,308	492	336	224	257	441	443	248	815	78
S	797	4,496	4,049	1,047	875	172	126	1,050	363	221	223	244	418	427	195	700	88
W	262	5,995	5,598	1,318	1,107	211	177	1,472	604	275	272	321	541	543	366	1,009	172
Farm																	
NE	125	6,081	4,858	1,654	1,507	148	149	1,180	461	314	183	221	437	429	222	703	86
NC	660	5,871	4,462	1,417	1,268	148	92	1,048	354	282	157	254	488	458	219	659	85
S	797	4,524	3,890	1,273	1,139	134	93	836	265	190	159	217	416	406	163	634	69
W	137	6,923	5,195	1,574	1,426	148	94	1,177	411	274	195	294	606	565	311	739	130

[a] NE = Northeast; NC = North-Central; S = South; and W = West.
[b] Y = Disposal income.
C = Total consumption expenditures.
X_1 = Total food.
X_2 = Food prepared at home.
X_3 = Food away from home.
X_4 = Tobacco and alcoholic beverages.
X_5 = Total housing.
X_6 = Shelter.
X_7 = Fuel, light, refrigeration, and water.
X_8 = Household operations.
X_9 = House furnishings and equipment.
X_{10} = Clothing, clothing materials, and services.
X_{11} = Personal and medical cares.
X_{12} = Recreation, reading, and education.
X_{13} = Transportation.
X_{14} = Other expenditures.

tions we used for estimation, we begin with the following system used by him to represent the structure of Engel curves:[4]

$$(1)\quad \begin{aligned} \ln X_i &= \alpha_{0i} + \alpha_{1i} \ln Y_p + U_i, \quad i = 1, \cdots, 14, \\ \ln C &= \alpha_0 + \alpha_1 \ln Y_p + V, \end{aligned}$$

where U and V are the disturbance terms.

Since Y_p is unobservable, solve (1) for the observable variables X_i and C, which results in

$$(2)\qquad \ln X_i = \alpha_i + \beta_i \ln C + W_i,$$

where $\alpha_i = \alpha_{0i} - \alpha_{1i}\alpha_0/\alpha_1$, $\beta_i = \alpha_{1i}.\alpha_1$, and $W_i = U_i - \beta_i V$. Since ln C and W_i are both functions of V, they are correlated. Thus the OLS estimate of β_i is biased and inconsistent.

Liviatan [12] has shown that the ratio of the OLS estimates of a_{1i} and a_1 (denoted by $\hat{a}_{1i}$ and $\hat{a}_1$) in

$$(3)\qquad \ln X_i = a_{0i} + a_{1i} \ln Y + u_1$$

and

$$(4)\qquad \ln C = a_0 + a_1 \ln Y + u_2$$

is a consistent estimate of β_i in (2). He also shows that this ratio is equivalent to using Y as an instrumental variable for C in (2). Liviatan's justification for using Y as an instrumental variable for C is that Y is closely correlated with Y_p and that during the survey period Y is exogenous to the consumer and does not depend upon expenditures. Although the ratio $\hat{a}_{1i}/\hat{a}_1$ is not an unbiased estimator of β_i, the bias is small.[5]

The above consistent estimate of β_i can be more conveniently derived by two-stage least squares (TSLS). This method consists of two stages: In the first stage find the predicted value, $\widehat{\ln C}$, of ln$C$ by fitting OLS to (4); in the second stage ln Y in (3) is replaced by $\widehat{\ln C}$ and then OLS is applied. It can be easily shown that the coefficient of $\widehat{\ln C}$ derived in the second stage is identical with the ratio $\hat{a}_{1i}/\hat{a}_1$. This is not surprising since, as is well known, formally TSLS is equivalent to the method of instrumental variables.

Of course $\hat{a}_{1i}$ is an estimate of the measured income elasticity for $X_i(\eta_{X_iY})$ and $\hat{a}_1$ is an estimate of the measured income elasticity of total consumption (η_{CY}). Although the ratio $\hat{a}_{1i}/\hat{a}_1$ is an estimate of the expenditure elasticity for X_i, it can be interpreted as the permanent income elasticity (η_{X_iY}).[6]

The above simple regressions are appropriate only for the data with equal N in each Y

[4] Although in his analysis Liviatan uses a linear model, he notes that the analysis remains valid when the linear model is replaced by an alternative logarithmic model. We used the double-log equation because of its usually superior fit, ease of interpretation, and considerable reduction of heteroscedasticity. Other forms such as linear, semi-log, and inverse semi-log were also fitted; and the results are not much different from those of log-linear form. Results reported in this paper are based solely on the log-linear form.

[5] See [4].

[6] The method for using the ratio $\hat{a}_{1i}/\hat{a}_1$ to estimate the permanent income elasticities for individual items was in fact suggested by Friedman [5].

class. The reasons are that the theory of consumer demand suggests that the demand for a commodity is a function of the consumer's income and of the prices[7] of the commodity and related goods under a given set of preferences; nearly all family budget analysts agree that N is the most important variable in this given set of preferences.[8] If N is not the same in each Y class, it should also be included in the regression as an explanatory variable. Including N in (2), we have

$$\ln X_i = \alpha_i + \beta_i \ln C + \gamma_i \ln N + W_i. \tag{5}$$

Even if N is exogenous and measured without error, it can be shown that the OLS estimate of γ in (5) is biased and inconsistent [12].[9] The biases in the OLS estimates of the coefficients of C and N are in opposite direction since these two variables are usually positively correlated.

Consistent estimates of the coefficients in (5) can be derived by using Y as an instrumental variable for C in (5) and N as its own instrumental variable [12]. As in the simple regression case, consistent estimates can be alternatively derived by TSLS. In the first stage of TSLS the estimate of $\ln C$ ($\widehat{\ln C}$) is obtained by fitting OLS to

$$\ln C = a_0 + a_1 \ln Y + a_2 \ln N + v_1, \tag{6}$$

where v_1 is a disturbance. In the second stage $\widehat{\ln C}$ replaces $\ln Y$ in

$$\ln X_i = a_{i0} + a_{i1} \ln Y + a_{i2} \ln N + v_2 \tag{7}$$

and then OLS is applied. The coefficient of $\widehat{\ln C}$ thus obtained is a consistent estimate of the expenditure elasticity for X_i or $\eta_{X_iY_p}$ if the PIH is accepted.

Comparison procedure

As Friedman has shown [5, pp. 206–7], the elasticity of X_i with respect to Y can be written:[10]

$$\eta_{X_iY} = \eta_{X_iY_p} \cdot \eta_{C_pY}, \tag{8}$$

where C_p is permanent consumption. Note that η_{C_pY} is the same as η_{CY}, since it is assumed that the transitory component of C averages to zero for a group of families as a whole. Since η_{C_pY} reflects the effect of transitory components of measured income and $\eta_{X_iY_p}$ the effect of tastes and preferences proper [5, p. 207], the measured income elasticity (η_{X_iY}) reflects both the consumers' tastes and preferences and the importance of transitory components of income.

If the PIH is accepted and permanent income is assumed to mean the same thing for the different categories of consumption,[11] then $\eta_{X_iY_p}$ is free from the influence of transitory factors affecting Y and hence can be used to test whether farm and nonfarm households have the same tastes and preferences. Equations are estimated by both OLS and TSLS to assess the role that stability of Y plays in the differences of consumption patterns between farm and nonfarm groups.

The equality of the entire set of regression coefficients between farm and nonfarm regressions or, equivalently, whether the samples of the two groups belong to the same regression, can be tested using an F-statistic developed by Chow [1].[12]

To test for equality of intercept or income elasticity the dummy variable technique was

[7] In cross-section studies of demand relationships prices are not treated as variables, because all the households faced the same market possibilities over the period of survey and there is very little, if any, perceptible variation in the prices confronting different households.

[8] For instance, Houthakker states that "the most important of noneconomic variables is probably family size, or more generally, family composition" [8, p. 136].

[9] Houthakker [7] claims that reliable OLS estimates can be obtained using data cross-classified by N and Y or C. However, our results indicate that there is high correlation between N and Y. Note that no data are classified by C.

[10] $$\eta_{X_iY} = \frac{dX_i}{dY}\cdot\frac{Y}{X_i} = \frac{dX_i}{dY_p}\cdot\frac{dY_p}{dY}\cdot\frac{Y}{Y_p}\cdot\frac{Y_p}{X_i} = \frac{dX_i}{dY_p}\cdot\frac{Y_p}{X_i}\cdot\frac{dY_p}{dY}\cdot\frac{Y}{Y_p} = \eta_{X_iY_p}\cdot\eta_{Y_pY}, = \eta_{X_iY_p}\cdot\eta_{C_pY}$$

since $\eta_{Y_pY} = \eta_{C_pY}$ by the hypothesis that C_p is a constant proportion of Y_p. Note that our notation is altered slightly from Friedman's.

[11] Friedman [5] explicitly assumes that the same concept of permanent income applies equally to total consumption and its individual categories, although he wonders if this assumption is correct. The concept or meaning of permanent income is interpreted in terms of the "horizon" of the consumer unit. Empirical results seem to suggest that this assumption is acceptable [11].

[12] The F-ratio is

$$\frac{(SSE_p - (SSE_1 + SSE_2))/K}{(SSE_1 + SSE_2)/(m + n - 2K)}$$

where SSE_1 and SSE_2 are the sum of squared residuals from the farm and nonfarm regressions. SSE_p represents the sum of squared residuals from the regression where all the m and n observations are pooled. K is the number of parameters in the model being estimated. Note that because grouped data were used the number of observations is the number of Y classes rather than the number of households. Note also that Chow's test in this case is equivalent to the analysis of covariance.

used. The model (for second-stage estimation) to test the equality of the intercept between farm and nonfarm families[13] becomes

$$
(9)\qquad \begin{aligned} \ln X_i = {} & b_{0i} + b_{1i} \widehat{\ln C} + b_{2i} \ln N \\ & + d_{11}D_{11} + d_{12}D_{12} + d_{21}D_{21} \\ & + d_{22}D_{22} + d_{23}D_{23} + w_1, \end{aligned}
$$

where $\widehat{\ln C}$ is the estimate of $\widehat{\ln C}$ obtained in the first stage estimation equation,[14] $D_{11}=1$ if the observation belongs to urban families and O otherwise, $D_{12}=1$ if the observation belongs to rural nonfarm families and O otherwise. The $D_{2j}(j=1, 2, 3)$ are the dummy variables for Northcentral, South, and West.[15] Since farm groups are taken as a base in (9), the anti-log of d_{11} shows the percentage difference in X_i between urban and farm groups.[16]

The dummy variables model for testing the equality of income elasticities is[17]

$$
(10)\qquad \begin{aligned} \ln X_i = {} & b_{0i} + b_{1i} \widehat{\ln C} + b_{2i} \ln N + d_{11}Z_1 \\ & + d_{12}Z_2 + d_{21}D_{21} + d_{22}D_{22} \\ & + d_{23}D_{23} + w_2, \end{aligned}
$$

where $Z_1 = D_{11} \widehat{\ln C}$ and $Z_2 = D_{12}\widehat{\ln C}$. d_{11} and d_{12} in (10) indicate the differences in $\eta_{X_iY_p}$ of farm and urban and farm and rural nonfarm groups respectively.

Equations (9) and (10) are also fitted by OLS with ln Y replacing $\widehat{\ln C}$, since as noted before it is of interest to compare the results with those obtained by TSLS to assess the role that stability of Y plays in the differences of consumption patterns between farm and nonfarm households. Results are also obtained for each of the four regions separately.[18]

Results

In estimating all of the equations, grouped data have been weighted by the number of households in each Y class. Income and family-size elasticities estimated by OLS and TSLS for farm, urban, and rural nonfarm families are presented in Table 2. The coefficient of determination is not given because, as Cramer [2] has shown, it is vastly overstated when an Engel curve is estimated by the use of grouped data rather than individual observations.[19] The results in Table 2 are estimated from the equation including three dummy variables to represent regions so that they are net of any regional effect. The coefficients of all dummy variables and all intercepts are significant at the 1 per cent level.

The family-size elasticities are quite small except for food and a few other items. The majority of them have a negative sign because, as an increase in N makes the family relatively poorer, the family, after an increase in expenditures on relatively necessary goods such as food, cannot but spend less on other commodities. The η_{CY} is much larger for nonfarm than for farm households, indicating that income of farm households is much more variable than that of nonfarm households.[20] The η_{X_iY}'s are similar for urban and rural nonfarm groups for many items; they are all substantially larger than those for the farm group. Some $\eta_{X_iY_p}$'s for the farm group are larger than corresponding estimates for the nonfarm group and, as implied

[13] It is assumed that the regression coefficients other than the intercept are the same for the sample groups.

[14] That is,

$$
\begin{aligned} \widehat{\ln C} = {} & \hat{b}_0 + \hat{b}_1 \ln Y + \hat{b}_2 \ln N + \hat{d}_{11}D_{11} + \hat{d}_{12}D_{12} \\ & + \hat{d}_{21}D_{21} + \hat{d}_{22}D_{22} + \hat{d}_{23}D_{23}, \end{aligned}
$$

where the coefficients with a "hat" are the OLS estimates.

[15] Namely, to net out differences in expenditure due to interregional differences in relative prices. The Northeast is taken as a base, i.e., its dummy variable is deleted to avoid singularity of the moment matrix.

[16] The percentage difference is calculated by $100(e^{d_{11}}-1)$. d_{12} is similarly interpreted for the difference between farm and rural nonfarm households. Note that the test of whether the farm households have the same income elasticity as the urban and rural nonfarm households is to use a t-test to see if d_{11} and d_{12} are significantly different from zero.

[17] In (10) the intercept and the other regression coefficients are assumed to be the same for farm and nonfarm samples. If a dummy variable regression is used to test the equality of both the intercept and the income elasticity between the samples, the results obtained from this regression would be exactly the same as those estimated by two separate regressions without using dummy variables. This is because the dummy variable equation breaks the pooled sample into farm and nonfarm original samples. For this proof see [6, pp. 225–226].

[18] The dummy variables of region are of course excluded from the regression in this case.

[19] Prais and Aitchison [14] have also indicated that the correlation coefficient based on grouped data is a very unsatisfactory estimate of the correlation in the population because there is no way of obtaining a valid estimate of the variance of the dependent variable from the grouped data. However, they have shown that grouping the individual observations in Engel curve analysis does not introduce any bias in the estimates of the regression coefficients, although the variance of the estimates is slightly larger than that based on individual observations. See [2].

[20] According to the PIH, the η_{CY} measures simply the fraction of the total variance of income in the group contributed by permanent income; hence the more stable income will result in a larger η_{CY}.

Table 2. Income and family size elasticities for farm, urban, and rural nonfarm households

Commodity	Urban households				Rural nonfarm households				Farm households			
	OLS		TSLS		OLS		TSLS		OLS		TSLS	
	Income elasticity	Family size elasticity	Income elasticity	Family size elasticity	Income elasticity	Family size elasticity	Income elasticity	Family size elasticity	Income elasticity	Family size elasticity	Income elasticity	Family size elasticity
C	.744 (.001)[a]	.126 (.002)			.742 (.004)	.151 (.005)			.519 (.006)	.214 (.007)		
X_1	.523 (.001)	.345 (.002)	.703 (.001)	.256 (.001)	.498 (.005)	.378 (.006)	.672 (.006)	.277 (.006)	.256 (.006)	.444 (.007)	.494 (.010)	.339 (.007)
X_2	.380 (.001)	.440 (.002)	.511 (.002)	.376 (.002)	.377 (.009)	.452 (.011)	.508 (.012)	.375 (.012)	.195 (.006)	.432 (.008)	.376 (.012)	.351 (.008)
X_3	1.216 (.005)	−.020 (.006)	1.635 (.007)	−.226 (.004)	1.158 (.015)	.379 (.018)	1.561 (.019)	.144 (.018)	.885 (.020)	.619 (.023)	1.706 (.035)	.254 (.024)
X_4	.727 (1.004)	−.038 (.005)	.977 (.005)	−.162 (.005)	.732 (.021)	−.088 (.025)	.987 (.028)	−.237 (.026)	.289 (.026)	.234 (.003)	.556 (.049)	.115 (.035)
X_5	.661 (.002)	.027 (.002)	.888 (.002)	−.085 (.002)	.783 (.008)	−.007* (.009)	1.056 (.009)	−.166 (.009)	.591 (.009)	−.032 (.011)	1.140 (.012)	−.276 (.008)
X_6	.573 (.003)	.005* (.004)	.770 (.004)	−.092 (.004)	.922 (.011)	−.130 (.014)	1.243 (.014)	−.317 (.013)	.619 (.015)	−.074 (.017)	1.194 (.024)	−.329 (.017)
X_7	.458 (.004)	.197 (.005)	.615 (.005)	.119 (.005)	.435 (.006)	−.004[b] (.008)	.587 (.008)	−.092 (.008)	.402 (.008)	−.083 (.009)	.775 (.014)	−.249 (.010)
X_8	.822 (.003)	−.017 (.004)	1.105 (.003)	−.156 (.003)	.920 (.008)	−.077 (.010)	1.240 (.010)	−.264 (.010)	.654 (.012)	−.503 (.014)	1.261 (.018)	−.322 (.013)
X_9	.996 (.005)	−.027 (.007)	1.338 (.007)	−.195 (.007)	.916 (.016)	.058 (.020)	1.235 (.021)	−.129 (.020)	.652 (.015)	.122 (.018)	1.257 (.026)	−.147 (.018)
X_{10}	.985 (.003)	.398 (.003)	1.325 (.003)	.231 (.003)	.991 (.009)	.548 (.011)	1.336 (.011)	.346 (.011)	.629 (.010)	.610 (.011)	1.212 (.012)	.350 (.009)
X_{11}	.655 (.003)	−.051 (.003)	.880 (.004)	−.162 (.004)	.672 (.009)	−.166 (.011)	.906 (.011)	−.303 (.011)	.476 (.010)	−.007* (.012)	.918 (.015)	−.204 (.010)
X_{12}	1.115 (.004)	.249 (.050)	1.499 (.004)	.060 (.004)	1.190 (.013)	.216 (.016)	1.604 (.017)	−.027* (.016)	.806 (.015)	.364 (.017)	1.554 (.022)	.032 (.016)
X_{13}	1.173 (.006)	−.091 (.007)	1.577 (.007)	−.290 (.007)	.948 (.017)	.191 (.021)	1.278 (.021)	−.002* (.020)	.837 (.018)	−.051 (.021)	1.614 (.026)	−.396 (.019)
X_{14}	1.005 (.010)	−.150 (.013)	1.351 (.012)	−.320 (.012)	.680 (.031)	−.028* (.038)	.916 (.042)	−.166 (.040)	.658 (.037)	−.354 (.043)	1.269 (.065)	−.625 (.046)

[a] Figures in parentheses are standard errors.
* Indicates that the coefficient is not significant at 5 percent level by two-tailed t-test .All others are significant at 5 percent level.

by the PIH [5, p. 217], the differences in $\eta_{X_iY_p}$ is smaller than that in η_{X_iY} between farm and nonfarm groups in most cases. Thus the smaller η_{X_iY}'s for farm households are partially attributable to more variable income.

The values of Chow's F-statistic are given in Table 3. Chow's test indicates that all regressions estimated by OLS differ significantly between urban and farm groups and between farm and rural nonfarm groups at the 1 percent level. Except for a few, the regressions estimated by TSLS also significantly differ between groups.

The F-values for each of the four regions for Chow's test (not shown in the table) indicate that the number of significant regressions is somewhat reduced. Four expenditure items by OLS and seven by TSLS in the Northeast; one by OLS and two by TSLS in the Northcentral; one by OLS and four by TSLS in the West; and three each by OLS and by TSLS in the South are not significantly different for farm and non-

Table 3. F-values for testing equality of farm and nonfarm regressions

Commodity	Urban vs. farm (d.f.[a] = 6,331)		Rural nonfarm vs. farm (d.f. = 6,333)	
	OLS	TSLS	OLS	TSLS
X_1	40.04[b]	57.54	39.11	91.41
X_2	32.98	54.60	26.45	31.24
X_3	36.20	14.42	14.11	6.86
X_4	11.71	23.64	14.56	10.57
X_5	104.98	84.87	24.30	15.32
X_6	118.81	103.22	69.22	11.52
X_7	7.85	10.64	15.66	11.79
X_8	99.81	60.18	36.81	25.03
X_9	5.65	2.51**	3.76	.98*
X_{10}	25.02	7.76	12.99	9.61
X_{11}	6.75	1.75*	4.54	2.85**
X_{12}	29.53	6.26	14.09	2.68**
X_{13}	4.18	3.51	6.34	5.24
X_{14}	5.62	1.75*	4.57	5.05

[a] d.f. = degrees of freedom.
[b] Unstarred figures are significant at the 1 percent level.
* Not significant at the 5 percent level.
** Not significant at the 1 percent level but significant at the 5 percent level.

farm (including both urban and rural areas) households at the 5 percent level. However, the general pattern of the regional results corroborates the national results since most regressions are significantly different for farm and nonfarm groups and the number of insignificant regressions by TSLS is slightly larger than by OLS. The slightly less marked differences obtained with the regional results than with the national results may be partly due to regional factors affecting tastes of households.

Comparisons between urban and farm groups and between farm and rural nonfarm groups indicate that a larger number of regressions differ significantly between urban and farm groups, as expected, since farm and rural nonfarm families are relatively similar with respect to community, price levels, tastes, and preferences.

In addition to the foregoing test of equality of the entire set of coefficients in two regressions, the dummy-variable technique was used to test whether households differ in income elasticity or in the level of consumption alone. Since results of tests of equality of elasticities and intercepts are identical,[21] only the former are given in Table 4. Note that the results were derived from the data of regional combination with farm households serving as a base.

The differences of income elasticities between the groups in Table 4 were derived by restricting the other regression coefficients to be the same for the three groups of households, as previously mentioned. Differences in elasticities between farm and nonfarm groups, either by OLS or TSLS, are all significant at the 5 percent level, except one case. The magnitude of the difference in elasticities by TSLS is smaller than that by OLS for most items. Thus, while the variability of income contributes to the larger difference in the measured income elasticities ($\eta_{X_i Y}$) between farm and nonfarm groups, tastes and preferences of the two groups are significantly different.

Since the results given in Table 4 were estimated from the dummy variables regression with farm group serving as a base, the coefficient in the table is the income elasticity of the urban or rural nonfarm group minus that of the farm group. Thus, .0189 indicates that the urban group's elasticity is greater than the farm group's by .0189. In the table, farm households' income elasticities for X_1 (total food) and X_2 (food prepared at home) are significantly greater than urban households' and rural nonfarm households' in both OLS and TSLS estimates. Elasticities of all other items obtained by OLS are larger for urban and rural nonfarm groups than for the farm group, with one exception. Slightly less than half of the TSLS elasticities for urban and rural nonfarm groups are smaller than for the farm group. Thus income variability is mainly responsible for the substantially underestimated measured income elasticities for farm households. The table shows that if the elasticities of both urban and rural nonfarm groups are larger than the corresponding elasticity of the farm group, then the difference between urban and farm

Table 4. Differences of income elasticities of farm households from those of urban and rural nonfarm households

Commodity	OLS: Difference of income elasticities between farm and Urban	OLS: Rural nonfarm	TSLS: Difference of income elasticities between farm and Urban	TSLS: Rural nonfarm
C	.0189 (.0003)[a]	.0101 (.0004)		
X_1	−.0054 (.0003)	−.0172 (.0004)	−.0186 (.0003)	−.0242 (.0003)
X_2	−.0141 (.0004)	−.0268 (.0005)	−.0240 (.0004)	−.0321 (.0005)
X_3	.0601 (.0010)	.0380 (.0012)	.0300 (.0010)	.0218 (.0012)
X_4	.0704 (.0011)	.0542 (.0014)	.0542 (.0012)	.0455 (.0014)
X_5	.0487 (.0004)	.0291 (.0005)	.0314 (.0004)	.0198 (.0005)
X_6	.0875 (.0007)	.0422 (.0009)	.0718 (.0007)	.0337 (.0008)
X_7	.0013 (.0006)	.0213 (.0008)	−.0108 (.0007)	.0148 (.0008)
X_8	.0669 (.0006)	.0431 (.0007)	.0462 (.0005)	.0320 (.0006)
X_9	.0124 (.0009)	.0115 (.0011)	−.0125 (.0009)	−.0018* (.0011)
X_{10}	.0178 (.0006)	−.0026 (.0007)	−.0072 (.0005)	−.0160 (.0006)
X_{11}	.0119 (.0005)	.0040 (.0007)	−.0050 (.0005)	−.0050 (.0006)
X_{12}	.0443 (.0008)	.0303 (.0010)	.0158 (.0007)	.0150 (.0008)
X_{13}	.0122 (.0011)	.0270 (.0009)	−.0169 (.0013)	.0114 (.0011)
X_{14}	.0449 (.0019)	.0346 (.0023)	.0216 (.0019)	.0222 (.0022)

[a] Figures in parentheses are standard errors.
* Not significant at 5 percent level by two-tailed t-test. All other coefficients are significant at 5 percent level.

[21] The results of the test are identical in the sense that if the $\eta_{X_i Y}$ is significantly greater (smaller) for the nonfarm group than for the farm group, the intercept is also significantly greater (smaller) for the nonfarm group than for the farm group.

Table 5. The t-values for testing equality of income elasticities between farm households and rural nonfarm households in the South with family size of two[a]

Method	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
OLS	30.4	28.7	7.8	9.8	7.8	10.2	1.0	2.6	3.6	19.6	5.6	15.9	4.3	3.7
TSLS	28.8	23.3	.5	3.6	.7	6.8	4.7	5.3	1.4	17.2	12.0	6.4	21.6	4.3

[a] With 14 degrees of freedom, t's 5 percent significant level is 2.145 and its 1 percent level is 2.947 for two-tailed test.

groups is greater than that between farm and rural nonfarm groups in most cases. If the elasticity for the farm group is larger than that for both urban and rural nonfarm groups, then the difference in the elasticity between farm and rural nonfarm groups is greater than that between farm and urban groups. On the whole, the magnitude of the difference between farm and rural nonfarm groups is less than that between farm and urban groups. This is in accord with our expectation, as noted earlier. The results for each region are the same as those given in Table 4, with a few exceptions.

Holding income level constant

In the analysis of Engel curves it has often been found that the magnitude of income or expenditure elasticity depends to a large extent upon the level of income.[22] Thus the clear difference in expenditure patterns between farm and nonfarm households, as given above, might be due to unequal income. The weighted average Y was considerably higher for urban than for farm families in each region (Table 1). A few comparisons between farm and rural nonfarm families can be made at nearly the same Y. In the South with family size of two, the weighted average Y for farm and rural nonfarm families is \$3,604 and \$3,507 respectively. The t-values for testing equality of their income elasticities estimated from the simple regressions (3) and (4) are set forth in Table 5.

The t-statistic given in Table 5 was calculated by[23]

$$(11)\quad \frac{b_R - b_F}{\sqrt{\frac{1}{2}S_R^2(1+\Sigma e_F^2/\Sigma e_R^2)+\frac{1}{2}S_F^2(1+\Sigma e_R^2/\Sigma e_F^2)}},$$

where the b's are the rural and farm income elasticities, the S's their standard errors, and the Σe^2's the sum of squared residuals. The t-values in the table indicate that differences of income elasticities between the two relatively equal income groups are at least as great as between any two groups compared earlier.

Farm and rural nonfarm households with two or more persons had about equal weighted average Y in the Northeast (\$6,078 vs. \$6,081) and in the South (\$4,496 vs. \$4,524). Equations (6) and (7) were fitted to data from the two groups. Chow's test indicates that, in the Northeast, the F-values by OLS and those by TSLS except for X_5, X_{10}, and X_{11} are significant at the 5 percent level. In the South the F-values by OLS, except for X_{10}, X_{12} and X_{14}, and those by TSLS, except for X_{10}, X_{12} and X_{13}, are significant at the same level. The differences are not much less than those between any other two groups with more unequal income level. Thus income level does not seem to be a determinant of the differences in consumption patterns between farm and nonfarm households.

Results with durable goods excluded

The above results indicate that differences in consumption patterns between farm and nonfarm groups are somewhat reduced when TSLS rather than OLS is used, because the influence of transitory income is reduced or eliminated in the TSLS estimates. However, since the X's and C above include expenditures on durables, the assumption of the PIH that the transitory components of C and X_i are both uncorrelated with permanent and transitory components of income and average zero for a group of families as a whole for any income class is not satisfied. To satisfy this assumption, X_i and C should be defined to exclude expenditures on durables but to include the depreciation of durables.

To assess more closely the role transitory components of income play in differences of expenditure patterns between farm and nonfarm families, the following durables are deducted from C and the appropriate X_i: house furnishings and equipment (X_9), purchases of automobiles, televisions, radios, phonographs, tape recorders, and musical instruments. Al-

[22] See, for instance, [15, 18].

[23] If the disturbances in the two simple regressions are normally distributed and have the same constant variance, then it can easily be shown that (11) has a t-distribution with degrees of freedom equal to the total number of observations minus four. This statistic is used to test the equality of the farm and rural nonfarm elasticities.

Economic Potential of the California Trawl Fishery*

DESMOND O'ROURKE

This paper presents a technique for estimating the physical yield function of a fishery when detailed biological and environmental data are lacking. The physical yield function of the California trawl fishery is incorporated in an economic model to show the relationship between maximum sustainable physical yield of the fishery and maximum economic yield. Maximizing the economic benefit of the fishery to society would involve a drastic reduction in resource use at a catch level considerably below the biological maximum sustainable yield. Only through marginal cost pricing can resources be allocated efficiently to the fishery.

DURING the last decade there has been much popular discussion about the sea as a major reservoir of food for a growing world population. However, because of the lack of adequate biological data, estimates of the productivity of the sea have varied so widely as to be of little value to policy-makers [4]. This paper describes a simple technique that can be used to estimate the economic potential of a specific fishery when information on the biological aspects of the fishery is not available. It points out the fundamental differences between production and cost curves appropriate to fishery production and the conventional curves that obey the law of variable proportions. The technique is applied in derivation of estimates of the economic potential of the trawl fishery in California, analysis of the economic impact of current firm behavior within the fishery, and suggestion of the direction in which the fishery must move to reap its long-run economic potential.

The California Trawl Fishery

A brief description of the California trawl fishery may be useful here in illuminating the technical discussion to follow. The trawl fishery is a major and distinctive component of the California fresh and frozen fish trade.[1] Trawler numbers and size and composition of the trawl catch are reported annually for 150–200 mile coastal zones: the Northern (Eureka), San Francisco, Monterey, and Santa Barbara coastal zones [12]. Vessels are equipped with trawls, large nets which, when seen from the air, look like a slingshot trailed behind the vessel. Fish enter between the arms of the sling and crowd forward into the narrower stem from where they can be more easily hauled aboard. Fishing is carried on in the narrow continental shelf along the California coast. The catch consists primarily of varieties of sole and rockfish, used for fresh and frozen fillets, and is a major source of raw materials for extensive processing, restaurant, and retailing facilities that supply California consumers. Catch composition, which has been relatively stable since 1950, has averaged 50 percent sole, 28 percent rockfish, and 22 percent all other species.

The California trawl fishery has had a difficult past and faces an uncertain future. A comparison of the annual average number of trawl vessels and of average volume and value of landings for the two nine-year periods, 1950–1958 and 1959–1967 shows that a declining fleet harvested about the same volume of landings and earned a 20 percent greater gross return in current dollar terms in the later period (Table 1). Anxiety about the ability of the California fish trade to maintain or expand its present level of supplies is widespread [13, p. 132]. Much of the anxiety stems from inadequate knowledge of the biological and economic potential of the entire California fishery.

In order to evaluate the economic potential of the California trawl fleet it was necessary to (1) develop a simple model to explain past and current levels of trawl landings and returns; (2) estimate the potential for growth in landings and returns, specifically by determining the annual maximum sustainable yield and the optimal number of vessels required to achieve that yield for each coastal zone and for all California; (3) indicate the biological and economic consequences of deviations from the maximum sustainable yield, both the consequences of overfishing and of fishing at the

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[1] Other groups of vessels and fishermen fish California waters for crab, salmon, albacore tuna, abalone, etc.

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Table 1. **Annual average number of trawl vessels and volume and value of landings by the California trawl fleet in 1950–1958 and 1959–1967**

Annual average for period	Northern (Eureka)	San Francisco	Monterey	Santa Barbara	California total
		Number of trawl vessels			
1950–1958	41	26	14	13	87[a]
1959–1967	36	22	09	16	72[a]
		Volume of landings (thousand pounds)			
1950–1958	18,732	8,782	3,918	1,621	33,053
1959–1967	16,519	9,162	3,541	4,344	33,566
		Value of landings (thousand dollars)			
1950–1958	1,022	487	210	131	1,849
1959–1967	1,076	619	210	280	2,185

[a] Excludes duplication. A vessel may be reported for more than one area in the same year.
Source: [19].

biological maximum; (4) provide a framework for estimating the impact on the trawl fishery of changes in key biological and economic variables; and (5) provide a guide for managers and policy-makers in making decisions about further investment, manpower, and development needs.

The Economic Model

The supply of fish from the trawl fleet is a function of the environmental factors that affect the fertility of the ocean and the economic factors that determine the effort man will expend in harvesting from the ocean. Interaction of supply and demand determines the economic return to society (both its producers and consumers) from the fishery. At this stage of our knowledge of environmental factors and given the limitations of currently available economic data, it would be impossible to capture in a single model the dynamic processes by which supply and demand in the trawl fishery are generated. However, the comparative-static model outlined here offers promise of effectively catching the essence of the major variables and relationships among variables that shape the fishery in California.

Supply

In analyzing a heterogeneous fishery such as the trawl fishery one is precluded by lack of data from examining supply in terms of recruitment, growth, and natural mortality of the many species involved. The approach adopted here is a variant of a simple yield model developed by Schaefer [16] which has been used in many biological studies of fisheries but only in one previous economic analysis, that of Northern lobster by Bell [1].

Schaefer showed that the general law of population growth of organisms living in a constant environment with a limited food supply could be applied to growth of fish populations. Specifically, he used the Verhulst-Pearl logistic

$$\frac{dP}{dt} = k_1 P(L - P) \tag{1}$$

where

P = current population (either biomass or numbers),
L = maximum population the environment can support, and
k_1 = constant.

This gave a parabolic curve for natural rate of increase of a population, with zero rate of growth at zero or maximum population and maximum rate of growth at $L/2$ (Figure 1).

In its natural state the fishery would tend to L. With fishing, the actual growth of the population would equal natural growth less fishing mortality. At successively lower levels of population between L and $L/2$ fishermen could take increasing yields while leaving the population at that level unchanged, provided catch equalled the natural rate of growth of population at that level. That is, for each level of population there was an equilibrium catch or yield. At $L/2$ the largest equilibrium catch could be taken in perpetuity without reducing the population. This point is most usually

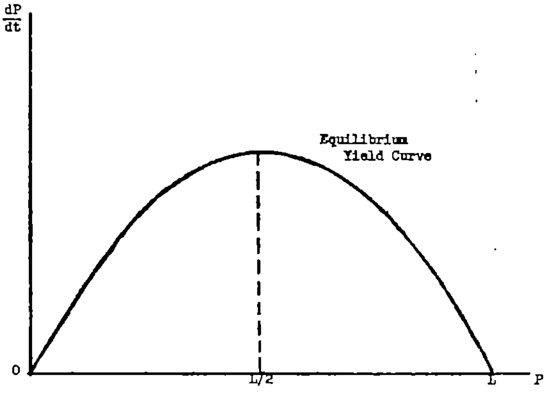

Figure 1. **Equilibrium yield curve of a fish population in a constant environment**

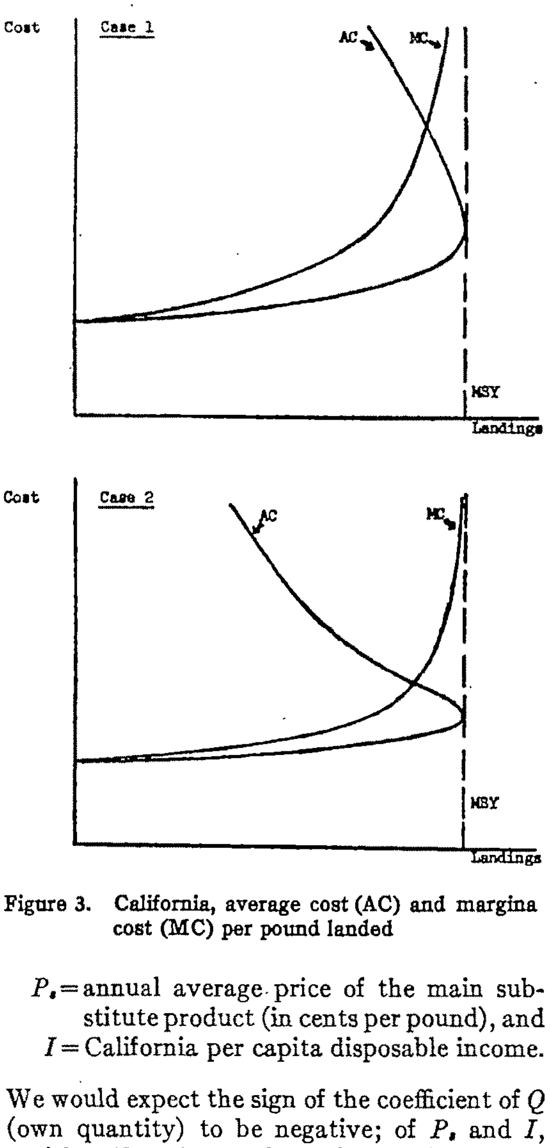

Figure 3. California, average cost (AC) and margina cost (MC) per pound landed

P_s = annual average price of the main substitute product (in cents per pound), and
I = California per capita disposable income.

We would expect the sign of the coefficient of Q (own quantity) to be negative; of P_s and I, positive. For given values of P_s and I in any year, (25) reduces to

$$P = c - dQ. \tag{26}$$

The total revenue function then becomes

$$PQ = cQ - dQ^2, \tag{27}$$

and the marginal revenue curve,

$$d(PQ)/dQ = c - 2dQ \tag{28}$$

To maximize total revenue, set (28) equal to zero. The level of landings that maximizes total revenue is then

$$\text{when } Q = c/2d, \text{ and} \tag{29}$$

$$PQ \text{ maximum} = c^2/4d. \tag{30}$$

Neither maximization of sustainable yield nor maximization of total revenue may be the actual or optimal criterion used by participants in the trawl fishery. The relationship of these and other possible criteria will be explored in a later section.

Empirical Results

Time series data for 1950–1967 were used to determine the maximum sustainable yield in each zone and the optimal number of vessels needed to produce that yield. Since annual observations were unlikely to be equilibrium observations, the data were averaged over three-year periods to more nearly approximate equilibrium observations in the manner described by Gulland [7]. The basic equilibrium yield functions derived are presented in Table 2; t-values are given in parentheses below each estimated coefficient.

Results support the hypothesis that catch per vessel diminishes with increased effort, as represented by number of fishing vessels. Sea surface temperature was statistically significant for the Monterey and Santa Barbara zones and for the total California yield function. Its influence in all cases was positive. However, more evidence is needed before this positive influence can be explained in biological terms. It may be that rockfish are more responsive to temperature changes than sole. The trend coefficient was significant at the 5 percent level in two zones. The negative time trend in the Northern area may be due to factors such as pollution, increased intensity of fishing, or the increasing presence of foreign vessels in or near the fishery. The positive time trend in the Santa Barbara zone may reflect the gradual opening up of new trawling areas in the zone. The poorer fit for the San Francisco zone may result from the inapplicability of the Gulland technique to a fishery that is frequently overfished with resultant disequilibrating influence on the population of the fishery.

Using the relevant values of F and T for 1967, the simplified quadratic yield functions expressing Q as a function only of V were derived from the equations in Table 2 and are presented in Table 3. Each relationship in Table 3 was then solved to find the maximum sustainable yield for each zone and the optimal number of vessels required to produce that maximum. For comparative purposes the results were contrasted with the actual state of the fishery for the year 1967 and with its average state for the

Table 2. Estimated yield functions for the trawl fleet in California, by coastal zones, 1950–1967[a]

Dependent variable	Independent variables				Statistical tests	
Catch per vessel in zone	Constant	Vessels	Temperature[b]	Time[c]	R^2	Durbin-Watson
Northern	−264.112 (.297)	−11.616 (4.459)[d]	+23.569 (1.462)	−9.333 (3.426)[d]	.697	.695
San Francisco	−1787.26 (.616)	−8.053 (.719)	+41.996 (.876)		.314	1.854[e]
Monterey	−3252.80 (2.060)	−21.799 (2.330)[d]	+68.363 (2.476)[d]		.512	.794
Santa Barbara	−1622.06 (1.967)	−23.139 (3.883)[d]	+35.661 (2.527)[d]	+20.635 (7.591)[d]	.910	1.158[f]
California	−1536.69 (2.655)[d]	−4.922 (9.102)[d]	+42.240 (4.330)[d]		.964	.831[f]

[a] Data used were averages for the years t, $t-1$, and $t-2$.
[b] Temperature data used were annual averages for specified 2° square areas in each zone. For California, the arithmetic average of annual data for the four zones was used.
[c] Time=1, 1950–1952 · · · =16, 1965–1967.
[d] t-test shows coefficient significant at the 5 percent level.
[e] No serial correlation present.
[f] Durbin-Watson test for serial correlation inconclusive.

Table 3. Simplified yield functions for the trawl fleet in California, by coastal zone, 1967

Coastal zone	Simplified yield function
Northern	$Q=852.20V-11.616V^2$
San Francisco	$Q=547.73V-8.053V^2$
Monterey	$Q=602.87V-21.799V^2$
Santa Barbara	$Q=705.09V-23.139V^2$
California	$Q=828.73V-4.922V^2$

years 1950–1967 (Table 4). The Northern zone landed catch in excess of the maximum sustainable yield in both periods. The number of vessels in the Northern zone was over 27 percent above the level required for maximum sustainable yield in 1967 and was the basic cause of overfishing. As noted previously, the available data on vessels operating in each zone is limited; accordingly, one must interpret estimates of the optimal number of vessels operating in the four coastal zones to mean optimal numbers at past levels of activity.

For the total California trawl fishery there was some excess effort in 1967. The effect of excess effort in one year on landings in subsequent years can be seen from a comparison of

Table 4. Estimated maximum sustainable yield and optimal number of trawl vessels in 1967 and actual landings and vessels in 1967 and on average for 1950–1967, by Coastal zone, California

Coastal Zone	Landings			Vessels		
	Maximum sustainable yield, 1967	Actual, 1967	Annual average, 1950–1967	Optimal, 1967	Actual, 1967	Annual average, 1950–1967
	thousand pounds			*number*		
Northern	15,629	18,733	17,626	37	47	38
San Francisco	9,311	6,895	8,973	34	19	24
Monterey	4,169	3,655	3,730	14	9	12
Santa Barbara	5,373	4,419	2,983	15	18	14
California[a]	34,482	33,702	33,312	100	93	88
California[b]	34,885	—	—	84	88	90

[a] Including duplication.
[b] Excluding duplication.

estimated maximum sustainable yield and actual landings in each year, 1950–1967, for the entire California fleet (Figure 4). Landings exceeded estimated maximum sustainable yield in 1950 and 1956. In the years immediately subsequent, landings fell below estimated maximum sustainable yield, the most notable decline in each instance occurring three years after the year of overfishing (1953 and 1959). The marginal overfishing in 1966 would appear to be leading to a similar sequence. Preliminary data available suggest that this may in fact have been the case and that the most serious overfishing continues to occur in the Northern and San Francisco zones.

Our equations enable us to estimate the sensitivity of maximum sustainable yield to changes in sea surface temperature. A one degree increase in 1967 temperature would have increased the maximum sustainable yield for California by 3.6 million pounds and the number of vessels required to produce that yield by four to 88 vessels. If past temperature patterns prevail in the future, in 75 percent of all years annual maximum sustainable yield will fall in the range of 31–36 million pounds, requiring 80–85 vessels.

The results so far discussed set the physical limits to expansion of the California trawl fleet in terms of number of vessels and annual landings. Undoubtedly, many more insights are

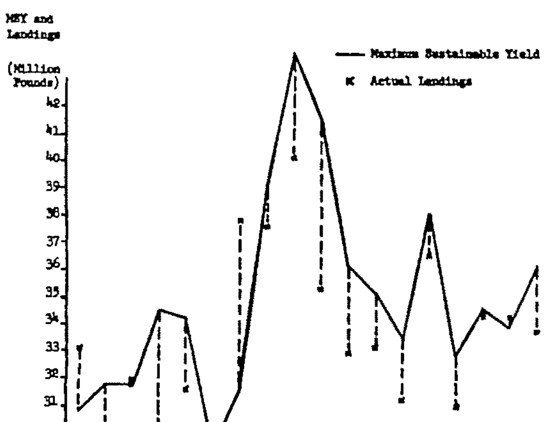

Figure 4. **California estimated maximum sustainable yield and actual landings, annually, 1950–1967**

needed into the biological and environmental factors affecting the physical limits observed. However, of greater economic import for the trawl fleet is the relationship between maximum physical sustainable yield and the market equilibrium towards which the forces of costs and returns, of supply and demand, would tend to lead the fleet.

The demand for the output of the trawl fleet in each zone and for all of California was estimated using single-equation least squares with price as the dependent variable. With the exception of the equation for Monterey, the Durbin-Watson statistics gave no evidence of serial correlation; multicollinearity was not a problem; and the signs of the coefficients agreed with theoretical expectations (Table 5).

The quantity coefficient was significant at the 5 percent level for all zones except the Northern. In that zone special institutional controls are exercised over prices and landings by producers and processors [13, p. 126]. The price of hamburgers in the United States significantly affected the average price received by the trawl fleet in all but one area. Hamburgers appear to be the type of beef with which sole and rockfish compete most directly in terms of price at the retail level. In the Santa Barbara zone price was more directly affected by price in the Northern zone, probably because of the close interfirm links between the two areas. California per capita personal income significantly affected price in the Northern zone and in all California but did not contribute to the explanation of demand in the other zones. The dummy variable was significant in two equations, reflecting improved marketing conditions that boosted annual average price in Santa Barbara in the 1960's by just over one cent per pound and in San Francisco by one and three-quarter cents per pound.

The elasticity of landings with respect to price for each area, as estimated from the above price equations, was greater than unity in all cases (Table 6). The implication for policy of this finding is that increased landings in all areas would bring a continued increase in total revenue. However, as illustrated in Table 4 and Figure 5, an overall increase of even 10 percent above average annual California landings for 1950–1967 would consistently lead to the risk of overfishing. A 20 percent increase could not be maintained. Clearly, maximizing total revenue from the trawl fleet cannot be adopted as a

Table 5. Estimated demand functions for the output of the trawl fleet in California, by coastal zones, 1950–1967

Dependent variable	Independent variables					Statistical tests		
Annual average price in zone[a]	Constant	Annual landings[b]	Price hamburgers[c]	Price Northern[d]	Income[f]	Dummy variable	R^2	Durbin-Watson
Northern	1.6502	−.00007304 (.910)	+.03142 (3.294)[e]		+.0009128 (2.968)[e]		.692	1.336
San Francisco	6.4115	−.0003884 (3.351)[e]	+.02593 (3.648)[e]			+1.7667[g] (7.940)[e]	.870	1.744
Monterey	3.4397	−.0002032 (2.556)[e]	+.03102 (3.450)[e]				.674	.978
Santa Barbara	8.8559	−.001452 (10.624)[e]		+.4522 (1.838)		+1.1366[h] (1.862)	.927	1.490
California	2.7439	−.00006601 (2.043)[e]	+.02870 (4.305)[e]		+.0009733 (5.056)[e]		.790	1.463

[a] In cents per pound.
[b] In pounds liveweight.
[c] U. S. retail price index, 1957–1959 = 100.
[d] Annual average price in the Northern zone in cents per pound, undeflated.
[e] t-test shows coefficient significant at the 5 percent level.
[f] California per capita income (in current dollars).
[g] Dummy = 0, 1950–1961, = 1, 1962–1967.
[h] Dummy = 0, 1950–1959, = 1, 1960–1967.

permanent criterion for decisions on expansion of the fishery. Given the restrictive physical limitations, maximization of total revenue in the long run could be secured by fishing as closely as possible to maximum sustainable yield.

A critical issue in determining the economic health of a fishery, and the costs and benefits to society from its operation, is an understanding of the aggregate decisions of fishermen and fleet-owners that lead to their taking a given catch in any year. Many writers assume that because of free entry and many small participants in a fishery, catch will tend to be expanded until average cost per pound landed equals price [5]. In contrast to the situation where participants expand landings until marginal cost equals price, there is a loss to society of the area between the marginal cost curve and the demand curve. Some writers have even advocated as a goal for participants in a fishery the expansion of landings to the point where marginal cost equals marginal revenue and the fishery in fact earns monopoly profits [18].

If as a working hypothesis we assume that

Table 6. Elasticity of trawl fleet landings with respect to price, California, by coastal zones, 1950–1967

Coastal zone	Elasticity
Northern	−3.923
San Francisco	−1.770
Monterey	−7.727
Santa Barbara	−1.787
California	−2.711

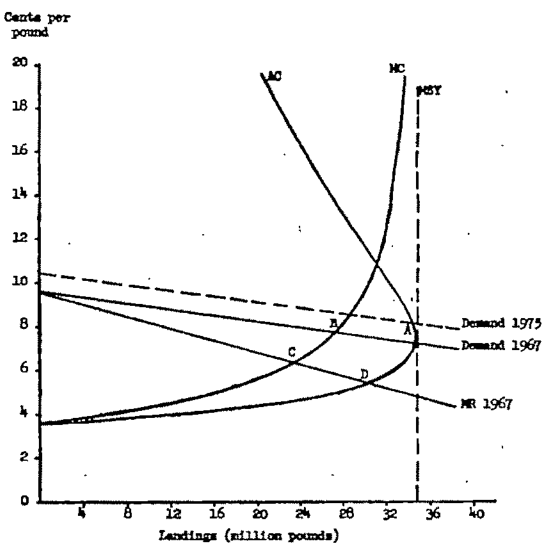

Figure 5. California: average cost, marginal cost, demand and marginal revenue curves, 1967

average costs per vessel in 1967 were $30,000 (including variable, fixed, and opportunity costs of capital and labor), the relationships developed previously for average cost (19) and marginal cost (20) enable us to determine which of the above three strategies were most closely followed by participants in each zone of the California trawl fishery. For given values of the exogenous variables, the 1967 price and marginal revenue curves in terms of landings were determined from the original demand equations (Table 7).

The intersections of the curves for California in Figure 5 show clearly that under the given cost assumption the trawl fleet catch in 1967 more closely approximated the level at point A where average cost equals price than would have been possible under a strategy of equating marginal cost with price, point B, or marginal cost with marginal revenue, point C. The loss to society from production at point A is represented by the area between the marginal cost curve and the demand curve to the left of point A. An approximate estimate of this loss in 1967 would be half a million dollars. A similar pattern was found in three of the four coastal zones for 1967.

One can conclude that the high capital cost of entry into the trawl fleet relative to other California fisheries is neither an effective barrier to entry nor a preventative of excess effort. However, there are reasons why many participants in the trawl fishery might not leave the fishery despite low returns. Processors own directly or indirectly many of the vessels in the trawl fleet. At times when catch regularly approaches maximum sustainable yield they may be willing to run their fishing operations at cost in order to secure adequate supplies of raw materials and may be content to make their profits from their processing and merchandising activities.

One possible escape from the present dilemma has been suggested by Bell in his work on Northern lobsters [1, p. 30]. He shows that, given cost and demand curves of the form developed here, at high levels of demand a production decision based on equating marginal cost to price will lead to production about the level of maximum sustainable yield and will restore to society the economic loss incurred under an average cost pricing strategy. However, assuming the same trend of price and income in 1967–1975 as in 1959–1967, we can estimate the possible upward shift in the demand curve for the output of the trawl fleet. By 1975 the demand curve will still cut the marginal cost and average cost curves below their intersection point as it does now, and participants will still tend to follow an average cost pricing strategy (Figure 5).

Table 7. Simplified price and marginal revenue curves in terms of landings, California, by coastal zones, 1967

Coastal zone	Price curve	Marginal revenue curve
Northern	$8.6664-.00007304Q$	$8.6664-.00014608Q$
San Francisco	$11.1835-.0003884Q$	$11.1835-.0007768Q$
Monterey	$7.0354-.0002032Q$	$7.0354-.0004064Q$
Santa Barbara	$13.4245-.001452Q$	$13.4245-.002904Q$
California	$9.6685-.00006601Q$	$9.6685-.00013202Q$

The economic optimum

From an economic viewpoint we can ignore all points to the right of maximum sustainable yield, since any yield thereafter can be obtained with less effort at lower cost to the left of maximum sustainable yield. In the range of feasible effort economics provides us with a simple criterion for finding the point of optimum effort. Effort (that is, the use of scarce economic resources of capital and labor) should be continued up to the point where the marginal cost of effort equals the price of the product or catch. Crutchfield has argued strongly that in fisheries subject to overfishing the maximum benefits can be realized only through public control [5, p. 21]. Bell contends that if this public control is exercised through a strategy of marginal cost pricing it will insure (1) economic efficiency and (2) that the resource will not be exploited beyond maximum sustainable yield [1, p. 27].

Based on our assumption of average costs per vessel of $30,000, the economic optimum yield of the California trawl fishery would have been about 27 million pounds, or less than 80 percent of the maximum sustainable biologically. This catch could have been taken by 44 vessels, half the number actually engaged. Clearly, any effort to establish an economically efficient trawl fishery will require significant reductions in the resources of capital and labor at present committed to the fishery. These reductions are unlikely to come about without public control.

Conclusions

The technique presented in this paper has been successfully applied to measuring the economic potential of the California trawl

fishery. While the technique cannot elicit the specific biological and environmental factors that have influenced past and current levels of landings, it can establish critical biological and economic relationships within a fishery. For the California trawl fishery we have shown the relationship of landings to fishing effort, the potential for growth in landings and returns, the maximum sustainable yield beyond which the fishery will be depleted, the current market equilibrium, and the economic impact on participants in the fishery and on society of present catch policies.

Our model of the California trawl fishery has indicated that the fishery is being operated near its present physical limits and at a low rate of return to the trawl fleet and society. Since many trawlers are owned by and provide a captive source of supply for fish processing firms, low returns on the fishing operation may be compensated for by higher returns on other firm activities. With an elasticity of demand greater than unity, the temptation for such firms to fish dangerously near maximum sustainable yield is strong. Overfishing appears to have occurred at least three times in the last twenty years. The model presented here can provide a framework for analysis of the costs and benefits of alternative policies to maintain the California trawl fishery at its full economic potential.

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A Market-Share Approach to the Foreign Demand for U. S. Cotton*

GHAZI SIRHAN AND PAUL R. JOHNSON

Direct estimation of export and import demand elasticities has plagued analysts with statistical problems. Here it is proposed to adopt a market-share model for the estimation of such elasticities. The share of a market, rather than quantity, is considered to be a function of the prices of competitors in the market. Such elasticities have been estimated for U. S. cotton in the United Kingdom and West Germany. These elasticities are more in accord with a priori reasoning than previous estimates.

THE theoretical and statistical difficulties inherent in the direct estimation of a country's export (or import) demand have been discussed by many economists, including Polak [13], Orcutt [12], and Morgan and Corlett [11]. An indirect way of estimating elasticities of demand has been used by Harberger [9, 10] and Zelder [16]. By estimating elasticities of substitution one can make inferences about the direct elasticities of demand.

As an alternative it is suggested that a market-share approach be considered in assessing the degree of competitiveness between a country's product and foreign competitors' products in an importing market. Such an approach appears especially favorable where varieties of the product exist and are identifiable with the country of origin in the minds of purchasers in the importing country. Market-share models have been applied to analysis and estimation of domestic demand for products characterized by quality variation. An important work is Telser's study on domestic demand for branded goods [15]. Telser advocated taking the market share of the firm as the relevant quantity variable and the price of a firm's branded product relative to those of other firms' products in a branded-good industry as the relevant price variable for measurement of a firm's demand schedule. Assuming the current market share of a firm's branded product to be a linear function of its lagged market share and a price variable, he estimated the short-run and long-run elasticity of a firm's market share.[1] The price elasticity of demand for a firm's brand was further shown to be equal to the elasticity of the brand's market share plus the elasticity of total sales (of all brands) with respect to the price of the brand. Cowling and Rayner [6] used a market-share model in their empirical study of the tractor market in the United Kingdom.

In this study a market-share model has been used to measure the short-run and long-run price elasticities of United States cotton share in selected import markets. Such information on the sensitivity of market share to price changes provides a basis for testing the hypothesis that higher American cotton prices relative to competitors' prices led to the decline in the U.S. share of European import markets. The import markets of the United Kingdom and West Germany were selected for investigation over the period 1953–1954 to 1966–1967. The nonavailability of data on prices of cotton in other European import markets limited the number of countries included in the study.

British and German Cotton Import Markets

Total U.K. imports of raw cotton have trended downward during most of the period considered. British imports averaged 1.0 million bales annually over the period 1960–1966, in contrast to approximately 1.5 million bales for 1953–1959. On the other hand, West German imports of raw cotton have maintained a relatively stable record, averaging annually 1.3 million bales for 1953–1966. In the same period, British and German imports of man-made fibers increased substantially.

Over 1953–1959 the U.S. share of British cotton imports averaged 39 percent but dropped to 30 percent for 1960–1966. The U.S. cotton share of German imports, however, had greater fluctuations as well as a decline; whereas it averaged 32 percent for 1953–1959, the American share of the German import market fell to 18.5 percent for 1960–1966.

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[1] Telser's market-share equation is the reduced form of a probabilistic Markov process model that attempts to explain consumers' brand loyalty and brand switches in the markets for coffee, frozen orange juice, and margarine.

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Table 1. Averages of relative price ratios and market shares for U. S. cotton and various competitors in United Kingdom and West Germany[a]

	United States versus				
	Mexico	Nicaragua	Syria	Iran	All competitors
			United Kingdom		
Price ratios					
1957–1961	1.02	1.05	1.02	1.03	1.04
1961–1966	1.00	1.04	1.01	1.01	1.02
Market shares (percent)					
1953–1959					39.1
1960–1966					30.0
			West Germany		
Price ratios					
1955–1960	1.03	1.08	1.03	1.07	1.05
1961–1966	1.00	1.04	1.00	1.01	1.02
Market shares (percent)					
1953–1959					32.0
1960–1966					18.5

[a] Based on Sirhan [14]; quality (grade and staple) for each country is shown there in Appendix Tables 9 and 10.

Prices of American cotton in the British Liverpool market have trended downward over the period 1953–1954 to 1966–1967. In 1953–1954 the average price of American 1 1/16 inch was 39.21 cents per pound; it gradually declined to 28.36 cents per pound in 1966–1967. At the same time prices of foreign competitors have also dropped. One may attribute the downward movement in cotton prices to relative increases in available supplies of both cotton and man-made fibers.

Table 1 presents average relative price ratios of U. S. and competitive cotton in the Liverpool and Bremen markets. The subperiod averages reflect a lessening of a disparity between U. S. and other cotton. Table 1 also shows the average market share for subperiods for the United States as against all competitors.

Sources of Data

Data utilized in the study are reported in Sirhan's Ph.D. dissertation [13]. Time series data on cotton imports and prices of selected cotton qualities by staple length and country of origin were obtained primarily from statistical bulletins of the U. S. Department of Agriculture (1960–1969) and from publications of the International Cotton Advisory Committee (1953–1961).

Theoretical Framework

Concept of an import market-share function

For the period of the study the world cotton economy on the supply side consisted of a relatively large exporter—the United States—and many small exporters, namely, countries like Brazil, Mexico, Peru, Pakistan, Turkey, Syria, Egypt, and Sudan. The main importers were Western Europe (e.g., England, Italy, France, and West Germany), Japan, and other Far Eastern countries. An important aspect of market structure in cotton has been the role of governmental programs. The U. S. program has attempted to curtail production and subsidize exports. The role of government makes the view that exporting countries can be considered as counterparts to firms in an industry a useful abstraction. Such a view, for instance, has been adopted by Fowler [7] for the cotton economy.

One analogy with industry market structure would be the "dominant firm" price leadership type of oligopoly model, as expounded by Cohen and Cyert [5] or Brennan [3]. Such an oligopolistic model, however, assumes a homogeneous product with the implication of perfect substitutability, whereas in the case of cotton certain quality differences exist among cotton exports from alternative competing sources which give rise, with transportation cost and institutional factors, to price differences in an importing country. Each exporting country, hence, is to some degree a "price maker" in an import market but differs from the "pure monopolist" in the sense that its cotton exports have close, but not perfect, substitutes.

In setting its pricing policy in a given foreign market, each exporting country has to consider the action of other exporters. From the standpoint of an individual exporting country, one way of accounting for the action of other exporters is to take their shipment as an independent variable in the demand function confronting that exporting country in a given import market. From an empirical viewpoint, however, problems can arise, for regressing the commodity exports of one country on price of its product and shipments of its foreign competitors to a given import market is unlikely to yield satisfactory estimates of the effects of both explanatory variables.

In view of the difficulties involved in the direct estimation of import demand for U.S. cotton, it seems appropriate to adopt an approach somewhat similar to that advocated by Telser [14] and others in estimating domestic demand for a differentiated product.

Taking the share of cotton in an import market as a function of the price of American cotton and the price of competing foreign

cotton in that market, one may write

$$(1) \qquad M_a = f(P_a, P_0),$$

where M_a represents the U.S. cotton share in an import market, or $M_a = q_a/Q$, where q_a is the quantity of American cotton imported by a given country and Q is the total cotton imports from all sources by that country, P_a is the price of American cotton, and P_0 stands for the weighted average price of cotton from other sources in the given country's import market.

If the price of imported American cotton, say, increased in comparison with other foreign competitors' prices, one would expect consumers in the importing country to switch to cotton from other sources (e.g., Mexican cotton), resulting in a decline in the U.S. cotton share in the given import market. Thus, M_a is a decreasing function of P_a and the slope of the U.S. cotton import market share hence is negative. The elasticity of U.S. cotton import share with respect to price of American cotton, expressed as $\partial M_a/\partial P_a \cdot P_a/M_a$, is also negative in sign and its estimation provides an indication of the magnitude of competition between American cotton and foreign cotton in an import market. A relatively high coefficient, in absolute terms, is indicative of a high degree of competition between the United States and other cotton exporters. One can further infer the price elasticity of foreign demand for American cotton from a knowledge of the elasticity of market share. The relation between the two elasticities can be expressed in the following manner:[2]

$$\frac{dq_a}{dP_a}\cdot\frac{P_a}{q_a} = \frac{dM_a}{dP_a}\cdot\frac{P_a}{M_a} + \frac{dQ}{dP_a}\cdot\frac{P_a}{Q},$$

where $dq_a/dP_a \cdot P_a/q_a$ is the price elasticity of demand for American cotton in the given country's import market and $dQ/dP_a \cdot P_a/Q$ is the elasticity of total import demand of that country with respect to price of American cotton.

The price elasticity of import demand for U.S. cotton in a given market is greater in absolute terms than the elasticity of United States cotton import market share except in the case where $dQ/dP_a \cdot P_a/Q$ is equal to zero.

[2] This formulation is mathematically identical with Telser's derivation of the relation between sales elasticity of demand for a firm's brand and the elasticity of a brand's market share.

Market-share model

In the preceding section an economic rationale was presented for examining the functional relation between the U.S. cotton share in an import market and the price of American cotton relative to prices of competing foreign cotton in that market. Underlying this relation, however, are certain postulates about consumer behavior in the importing country.

First, it is assumed that the utility functions of purchasers include qualities of cotton that are identifiable with the countries of origin.[3] Second, it is assumed that these imported cotton products are close but not perfect substitutes, so that an increase in price of, say, American cotton will not lead to its disappearance from the import market or a fall in price of American cotton will not lead to the extinction of competing cotton varieties and complete dominance of the market. A third assumption is that if the price of an exporting country's cotton changes, consumers will change their purchases of the country's product gradually rather than instantaneously since it is not known to them whether the price change is temporary or permanent.

Underlying the market share of a cotton exporter is the purchasers' demand in the import market; and changes in an exporter's cotton market share reflects shifts in import demand. One can distinguish between the short-run and long-run cotton market share of a country on grounds similar to those in demand analysis. An exporter's long-run equilibrium cotton share reflects the desired level of purchases of that country's product by purchasers in the import market. Since it has been assumed that purchasers adjust their pattern of consumption gradually, only a fraction of the expected or long-run market share can be achieved within a specified period. Once an exporting country's long-run market share function and partial adjustment function are specified, the well-known partial adjustment reduced form equation can be derived from the structural relations.

The equation used in this study is of the form:

$$(2) \quad M_{at} = \gamma a + \gamma\beta P_t + (1-\gamma)M_{at-1} + \gamma e_t$$

where P_t is the ratio of U. S. price to the average of other prices. This transformation is necessary

[3] Less abstractly, it is production functions of raw cotton users that would include different qualities.

to avoid the severe multicollinearity inherent in the two prices.

The parameters to be estimated are γa, $\gamma\beta$, and $(1-\gamma)$. Once $(1-\gamma)$ is known, γ, a, and β can be computed. The coefficient $\gamma\beta$ stands for the short-run response of market share to price changes and β denotes the long-run response of market share to price changes.

Letting Roman letters stand for estimates of parameters, the long-run response is b_1 divided by $(1-b_2)$. If the coefficient b_2, is between 0 and 1, the long-run elasticity of market share is greater than the short-run elasticity.

Equation (2) makes possible the estimation of both the long-run and short-run response of U.S. cotton market share in the import market to price changes. The coefficients of such an equation, according to Griliches [8], are statistically consistent as long as the price variable and the lagged market-share variable are independent of the "true" residual error in the regression equation. But the existence of serial correlation in the disturbance will yield inconsistent estimates. A positive serial correlation will lead to an upward bias in the coefficient of the lagged market-share variable and a downward bias in the coefficient of the price variable.[4]

Statistical Findings

Three alternative regression equations were used to estimate the short-run and long-run price elasticity of United States cotton market share in the British and German import markets for 1953–1954 to 1966–1967:

(i) $M_{at}=b_0+b_1P_t+b_2M_{at-1}+u_t$

(ii) $M_{at}=b_0+b_1P_t+b_2M_{at-1}+b_3T+u_t$

(iii) $\log M_{at}=b_0+b_1\log P_t+b_2\log M_{at-1}+u_t$

where all variables except T have been defined earlier. T is a trend variable, years and u is assumed to be normally and independently distributed.

Estimates for the British market

Table 2 presents results obtained from using alternative forms of the United States cotton market-share equation. It can be seen that all coefficients of the price variable (b_1) of the four equations are significantly different from zero at the 5 percent probability level and have the proper sign. Two of the four coefficients on lagged market share are also significant at the 5 percent level.

The short-run and long-run elasticities of United States cotton market share were computed on the basis of the coefficients obtained. Table 3 presents the obtained elasticities of market share with respect to price, as well as the coefficients of adjustment corresponding to equations (1) through (4) of Table 2. It can be seen that the long-run elasticities, as expected, are greater in absolute value than those of the

[4] For a verification of these directional relationships, see Griliches [8].

Table 2. U.S. cotton share in the British import market: statistical results, 1953–1954 to 1966–1967

Equations	Dependent variable $M_{at}=(q_a/Q_T)t$	Constant term b_0	Regression coefficients of: Price variable when $P_t=P_{at}/\bar{P}_{0t}$ b_1	Lagged market share M_{at-1} b_2	Trend, T b_3	Standard error of estimate	Multiple correlation coefficient R
Linear	where						
1	Q_T = aggregate imports from all sources	2.8177	−2.6158 (1.3003)[a]	0.5693 (3.3015)		0.1286	0.5584
2	Q_T = aggregate imports from five sources[b]	2.1638	−1.9005 (0.7743)	0.7205 (0.2953)		0.1008	0.634
3	Q_T = aggregate imports from all sources	2.7282	−2.3171 (0.8116)	0.4451 (0.2534)	−0.02166 (0.0080)		0.752
Logarithmic							
4	Q_T = aggregate imports from all sources	0.0592	−2.8859 (1.1436)	0.7391 (.2959)		0.04382	0.642

[a] Numbers in parentheses are standard errors.
[b] Includes the United States, Mexico, Nicaragua, Syria, and Iran.

Table 3. Estimates of short-run and long-run elasticities of U.S. cotton share in the British import market

Equations	Short-run response $b_1=\gamma B$	Short-run elasticity[a]	Long-run elasticity	Rate of adjustment $\gamma=1-b_1$
Linear				
1	−2.62	−8.67	−20.16	0.43
2	−1.90	−2.70	− 9.67	0.28
3	−2.32	−7.70	−14.0	0.55
Logarithmic				
4		−2.89	−11.1	0.26

[a] It is suspected that significant serial correlation of the error could have biased upward some of the above values. The Durbin-Watson test could not be applied to evaluate the degree of serial correlation because of the inclusion of a lagged variable among the independent variables.

short run. The short-run market-share elasticities range from −2.70 to −8.67, while the long-run elasticities range from −9.67 to −20.16. However, the long-run elasticity estimates corresponding to equations (1) and (2) are of dubious value since the coefficients of lagged market share are statistically nonsignificant. The short-run and long-run elasticities of market share corresponding to equation (4) are respectively −2.89 and −11.1. The adjustment coefficients corresponding to that equation is 26 percent, which is plausible and consistent with the finding of researchers using simple expectation models.

On the basis of such relatively large computed elasticities of market share with respect to price, one may conclude that there is a high degree of competition in cotton imported by the United Kingdom from the United States and other sources, the reason being that the United States and other cotton exporters to the British market operate on the elastic section of their export market-share curves. One may further venture that if any of these exporters lower the price of their products, others will do the same rather than face a loss of market share. According to the comparatively acceptable elasticity values of equation (4), a 1 percent increase in the relative price ratio of U.S. cotton to that of competitors will lead to a reduction in the American cotton market share by 2.9 percent in the short run and by 11.1 percent in the long run.

The question next arises: What would be the price elasticity of British import demand for American cotton on the basis of the preceding market-share estimates? The price elasticity of British import demand for American cotton exceeds the elasticity of market share by an amount equal to the elasticity of total British cotton imports with respect to price of American cotton. An attempt to estimate statistically the elasticity of total imports was made but yielded unsatisfactory results. However, assuming the change in total imports with respect to price of American cotton, dQ/dP_a, to be -2096×10^3 pounds percent, and multiplying by the average price quantity ratio, where

$$P_a/Q = \frac{32.16}{1253 \times 5 \times 10^5},$$

Table 4. U.S. cotton share in the West German import market: statistical results, 1953–1954 to 1966–1967[a]

Equations	Dependent variable $M_{at}=(q_a/Q_T)_t$	Constant term b_0	Regression coefficients of: Price variable, when $P_t=P_{at}/\bar{P}_{at}$ b_1	Lagged market share, M_{at-1} b_2	Trend, T b_3	Standard error of estimate	Multiple correlation coefficient R
Linear 1	where Q_T = aggregate of imports from all sources	2.0734	−1.8456 (0.8566)[b]	0.3119 (0.3035)		0.1458	0.563
2		2.7971	−2.2761 (0.6130)	0.1110 (0.2206)	−0.02819 (0.0083)	0.1021	0.836
Logarithmic 3		−0.4594	−8.9853 (3.8015)	0.1692 (0.2997)		0.2586	0.610

[a] Dependent variable is in logarithmic form, whereas independent variables are linear.
[b] Numbers in parentheses are standard errors.

one obtains −0.11.[5] This may be taken as an estimate of the elasticity of British cotton imports with respect to price of American cotton and may represent the amount by which the price elasticity exceeds the cotton market-share elasticity.

Estimates for West German market

Table 4 presents the results of the different specifications for the West German market for 1953–1954 to 1966–1967. Coefficients of the price variable are statistically different from zero at the 5 percent probability level, and all have the expected negative sign. However, all coefficients of the lagged market-share variable are statistically not different from zero and therefore nonsignificant.

The short-run and long-run elasticities of U.S. cotton market share as well as the adjustment coefficients were computed on the basis of the estimated regression coefficients and are presented in Table 5. The short-run market share elasticities range from −7.6 to −9.4. Long-run elasticities are based on nonsignificant adjustment coefficients but are in the neighborhood of −10 from such estimates.

Table 5. Estimates of short-run and long-run elasticities of U.S. cotton share in the West German import market

Equations	Short-run response $b_1 = \gamma B$	Short-run elasticity	Long-run elasticity	Rate of adjustment $\gamma = 1 - b_2$
Linear				
1	−2.68	−7.62	−11.04	0.69
2	−2.60	−9.39	−10.67	0.88
Logarithmic				
3		−8.98	−10.82	0.83

Conclusion

The relatively large estimates of the short-run and long-run elasticities of market share are indicative of a high degree of sensitivity of American cotton share in the two import markets to price changes and substantial degree of competition in cotton imported from the United States and other sources. The loss in U. S. cotton market share during the period studied would have been greater had it not been for the reduction in price of American cotton relative to competitors.

This conclusion is also supported by the high estimates obtained for the elasticity of substitution between cotton products from the United States and other competing sources ranging from −11 to −19 in the British markets and −10 to −18 in the West German market.[6] These estimates are larger than those implied by previous studies [1, 2]. The difference is in the direction expected by the authors. Estimates in the neighborhood of 3 and 4 imply substantial monopoly power for the United States. A long-run monopoly position seems untenable. In addition to the difference in technique, the data for the current study are different from those of most earlier studies. Postwar data probably reflect better-functioning markets than data from the 1930's. Our judgment, then, is that both technique and data combine to give more reasonable estimates of the demand elasticities for an export item.

[5] This is based on the Cathcart finding [4] that a one-cent-per-pound change in the Liverpool price of cotton leads to a change in the opposite direction of 0.04 pound per capita in Foreign Free World mill consumption of cotton. Multiplying this estimate by the population of the United Kingdom (52.4 million) yields -2096×10^{8} pounds per cent.

[6] On the basis of the estimated elasticities of substitution, the price elasticity of import demand for United States cotton was found to be −6.21 in the British market and −8.3 in the West German market. For exposition of procedure and findings, see Sirhan [14].

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Effects of Supply Variations on Costs and Profits of Slaughter Plants*

LAWRENCE A. DAELLENBACH AND LEHMAN B. FLETCHER

Preferences of the firm for stable or varying flows of raw products are considered. A decision model involving rate and hours of plant operation is developed to measure the impact of supply variations on plant costs and profits. Situations in which the firm can and cannot predict raw material receipts with certainty are simulated. Varying supplies were found to raise costs of slaughter, but plants with stable supplies lose profits as long as product and input prices vary. Therefore individual firms, especially those that can forecast with a high degree of success, are unlikely to prefer stable to varying supplies.

INSTABILITY in agricultural processing industries often results from variations in the supplies of farm products available to processing plants. To be sure, the processing firm is also likely to be uncertain about other variables; prices of other inputs, qualities of raw-material supplies, and demand conditions for the processed products each may vary and none be subject to prediction with certainty.

Variation in raw-product supplies alone does not imply uncertainty, however, for although raw-material supplies may vary the firm may be able to predict the variation. Moreover, quality variations at the firm level should not be viewed separately from fluctuations in raw-product and processed-product prices. Optimal firm output for each production period is a function of the processing margin and other decision variables and will vary from period to period in response to anticipated or actual changes in them.

Previous studies usually have been concerned with the effects on annual plant costs of short-term (month-to-month or week-to-week) variations in rates of operation. The general implication of these studies is that uniform flows of raw materials are preferred to unstable supplies.[1]

In this paper we reconsider the preference of the firm for uniform flows of raw materials. Our argument is developed on the basis of a given plant that plans its production on a weekly basis. We consider both cost and revenue effects of supply and price variability and simulate situations in which the firm can and cannot predict with certainty. At the end we suggest some implications of our results for firm and industry stabilization programs.[2]

Processing and Procurement Costs

We synthesized the cost structure of a hog slaughter plant with a designed capacity slaughter rate of 310 head per hour.[3] The plant was a "kill and chill" facility with production organized on a single overhead rail assembly-line basis that featured a succession of specialized stations. These included driving of livestock to the kill floor, killing, dehairing, eviscerating, final preparation of the carcass for the cooler, head workup, viscera separating and cleaning, and offal packing. Cleanup, maintenance, and supervision costs were also included. Primarily because of the reluctance of firms to release data on plant costs we relied on accounting records from a small number of Iowa plants and supplementary engineering data to establish the input-output relations underlying the cost estimates. Consequently the estimates presented here cannot be considered as repre-

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[1] For example, Logan [5] has shown that an irregular flow of livestock supply forces slaughter plants to operate at less than capacity during periods of low supply and to work overtime during periods of high supply. He concluded that packers may wish to consider a more closely integrated relationship with feedlots because of the opportunity to reduce average costs through a more uniform supply of animals.

[2] An important theoretical analysis consistent with our approach is given in [7] in which Richard R. Nelson considers both firm and industry effects of demand variations and the ability of firms to predict prices.

[3] This size was chosen for two reasons: (1) Most plant economies of scale appear to be realized at this size of plant, and (2) plants of this size are relatively numerous in Iowa [2, p. 28]. "Capacity" is used in the economic sense of the rate of output where unit costs reach their minimum.

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sentative of all plants of similar size. Only costs relevant to firm decisions in the short run were considered; hence fixed costs were excluded from the analysis.

Plant costs

Slaughtering costs in relation to weekly output were estimated by taking into account both the rate of operation per hour and the number of hours worked per week [1, 4]. A single-shift, five-day week pattern of operation was established. It was assumed that the plant would operate at one of three hourly rates—230, 260, or 310 head per hour—and that the rate could be changed only at the beginning of a week. Following the industry pattern, it was assumed that the plant labor force was contracted on a weekly basis and that a minimum of 36 hours had to be paid to each worker scheduled to work on Monday morning. Overtime wages were paid for all hours over 40 worked each week; weekend and double-shift operations were not considered. Weekly slaughter was limited by an arbitrary assumption of a maximum of 50 hours of operation per week.

This pattern may not reflect realistically any given plant, but the assumptions appear to be representative of the general conditions under which plants in the industry operate. Rates of operation are usually confined to a few discrete choices and changed infrequently. Weekly volumes are often limited by some bottleneck in the plant's facilities; e.g., weekly slaughter volume cannot exceed the capacity of the plant's cooler.

In functional form, labor costs for week t were represented by

$$(1) \qquad L_t = f(w, M_r, b, h_t)$$

where w is the basic hourly wage level including fringe benefits, M_r is the manning requirement (the number of workers in the efficient crew) for the rth slaughter rate, b is the composite fringe benefit coefficient, and h_t is the number of operating hours during week t.

Utility and miscellaneous supply and service requirements were assumed constant per unit of output. Therefore total variable costs were written

$$(2) \qquad V_t = L_t + ms_t$$

where s_t is the level of output, m is the utility and miscellaneous expense per unit, and L_t is the labor cost.[4]

Total variable and average variable slaughter costs for each rate of operation are shown in Figure 1. The total variable cost curves are kinked at the weekly volumes corresponding to 36 and 40 hours of operation at each rate, reflecting the labor cost function. The average variable cost curves for each rate are u-shaped, with the minimum average variable cost occurring at 40 hours of operation. The envelope of the average cost curves, illustrated by the heavy shading, indicates the minimum-cost rate of operation for each level of weekly output.

Procurement costs

Procurement costs were defined to include expenses directly attributable to live animal procurement, exclusive of the live purchase price.

[4] Detailed data and explanation of plant costs are given in [2, pp. 27–60]. Additional data on labor costs are given in [6]. The basic cost equations were:

	Hours of Operation		
	$h_t<36$	$36\leq h_t\leq 40$	$h_t>40$
Rate	$L_t=(1+b)(36)K_r$ $M_t=mrh_t$ $V_t=L_t+M_t$	$L_t=(1+b)h_tK_r$ $M_t=mrh_t$ $V_t=L_t+M_t$	$L_t=(1.5h_t+40b-20)K_r$ $M_t=mrh_t$ $V_t=L_t+M_t$
$r=230$ $r=260$ $r=310$	$V_t=8740.22+79.58h_t$ $V_t=9675.94+89.96h_t$ $V_t=10600.85+107.26h_t$	$V_t=322.36h_t$ $V_t=358.74h_t$ $V_t=401.73h_t$	$V_t=-2427.84+383.06h_t$ $V_t=-2687.26+425.93h_t$ $V_t=-2944.68+475.34h_t$

where

K_t=Labor cost for one hour at rate r (not including fringe benefits)
h_t=Hours of production time, week t
b=Composite fringe benefit coefficient
L_t=Total labor cost, week t (including fringe benefits)
M_t=Total miscellaneous cost, week t
m=Miscellaneous cost per unit
V_t=Total variable costs
$K_{230}=202.32$
$K_{260}=223.98$
$K_{310}=245.39$
$b=0.2$
$m=0.346$

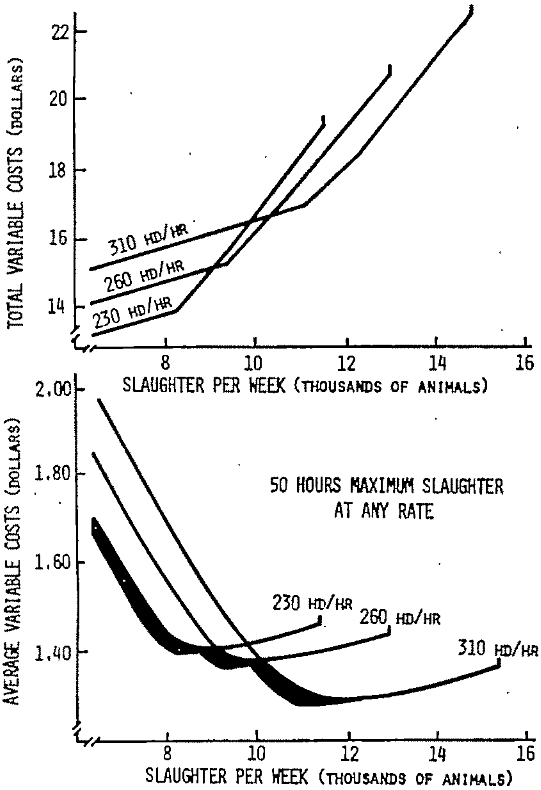

Figure 1. Weekly variable plant costs in relation to rate and volume of slaughter

Buying activities were simplified by assuming that all hogs were purchased through buying stations that operated each week regardless of fluctuations in available supplies.[5] Buying-station operating costs were treated as fixed because no empirical relation between either distance from the plant or number of animals purchased at buying stations and costs was found in the actual plant records. At-plant assembly costs were also regarded as fixed. Since these fixed costs are not relevant for short-run operating decisions, only variable transportation costs were included in the analysis.

Transportation costs from farm to plant were assumed to be paid by the plant. Transportation costs were related to the density of available supply each week and the number of livestock procured. All livestock processed in a week were assumed to be slaughtered that same week. The following transportation cost function was estimated:

[5] This assumption is unrealistic but our intent was not to determine an optimum procurement organization for the plant.

$$(3) \qquad R_t = 0.173s_t + 0.0025s_t(s_t/d_t)^{1/2}$$

where for week t: R_t equals total transportation costs, s_t equals the number of animals purchased, and d_t equals the density of livestock availability.[6]

Variations in Weekly Slaughter

Weekly slaughter for the tth week (s_t) can be defined in terms of the plant slaughter rate (r_t) and the hours of operation (h_t) as

$$(4) \qquad s_t = r_t \cdot h_t$$

Annual slaughter(s) for the plant is

$$(5) \qquad s = \sum_{t+1}^{52} s_t$$

Aggregate data were available for weekly slaughter of federally inspected plants (S) in the northwest subregion of the North Central region. These data were used to compute means ($\bar{S}$), variances (σ_S^2), and coefficients of variation ($CV_S = \sigma S/\bar{S}$) for weekly slaughter in the region for 1965, 1966, and 1967. Also, a weekly regional slaughter index, X_t, was defined:

$$(6) \qquad X_t = \frac{S_t}{\bar{S}}$$

Other studies of livestock variation and costs have applied a regional index to individual plants. That procedure implicitly assumes that each plant receives a constant share of the available supplies and that this share does not vary from one period to another. To simulate the many factors that disturb the constancy of a given plant's market share, a plant slaughter index was formed by adding a random, independent, and normally distributed term N, with zero mean and variance σ_n^2, to X_t. By construction, the variation of the new plant slaughter index will be higher than the variation of S_t. By choosing a mean weekly output (and consequently an annual output) for the plant, X_t and N can be used to generate a series of weekly slaughter levels that can then be represented by a mean, $\bar{s}$, variance σ_s^2, and

[6] We estimated the transportation cost/head/mile function $t = a + Bm$, where a equaled \$0.173, B equaled \$0.0054, and m equaled the number of road miles from farm to plant. Given a uniform livestock density (i.e., uniform number of available hogs per square mile per time period) and a tilted-square market area imposed upon a grid system of roads, the transportation function is $R_t = s_t[a + (2/3)B(s_t/2d_t)^{1/2}]$, which by substitution gives equation (3). For a general derivation, see French [3, pp. 771–2].

coefficient of variation, CV_s. Also, by systematically increasing the variance of the random variable, greater fluctuations in weekly slaughter for the plant can be generated for the same level and variation of regional slaughter. Of course, other plants could experience less-than-average variation. No analysis of the relation of plant to regional variations appears to have been done.

Model I: Stable vs. Variable Slaughter

This model was developed to measure the impact of different levels of weekly slaughter variation on *in-plant* slaughter costs under a variety of conditions and strategy options available to the firm. The following general procedure was used to measure the cost impact:

1. An annual slaughter volume was chosen. If this annual slaughter is distributed evenly over the year, a stable weekly slaughter results.
2. Total annual cost of producing this stabilized weekly volume was determined.
3. The same annual volume was distributed over the 52 weeks, using a plant slaughter index to impose on the firm four levels of weekly fluctuations as measured by the coefficient of variation: $CV_s = .18$, $CV_s = .23$, $CV_s = .29$, and $CV_s = .35$. The lower level was set slightly above the regional variation for the period. The higher levels would apply when the individual plant variation substantially exceeded the regional pattern.
4. Total cost of producing the annual volume, given the slaughter fluctuations, was determined.
5. The cost impact of stabilization was defined as the *decrease* in cost per head of slaughtering a stable weekly volume from the cost per head under the imposed variable conditions.

Hourly slaughter rate fixed for year

One strategy open to the firm is to fix the hourly slaughter rate for the year, e.g., 230 head per hour, and adjust to weekly livestock receipts by altering the hours worked per week.[7] Forecasting weekly livestock receipts was irrelevant, since the slaughter rate was fixed and the firm could adjust the weekly hours of operation to coincide with the available supply.

[7] Even though this is not the most efficient production strategy, a firm may choose this alternative since each hourly slaughter rate is associated with a specific crew size and altering the labor crew on a weekly basis may prove to be costly in terms of labor relations and retraining costs, especially for interior plants operating in small towns.

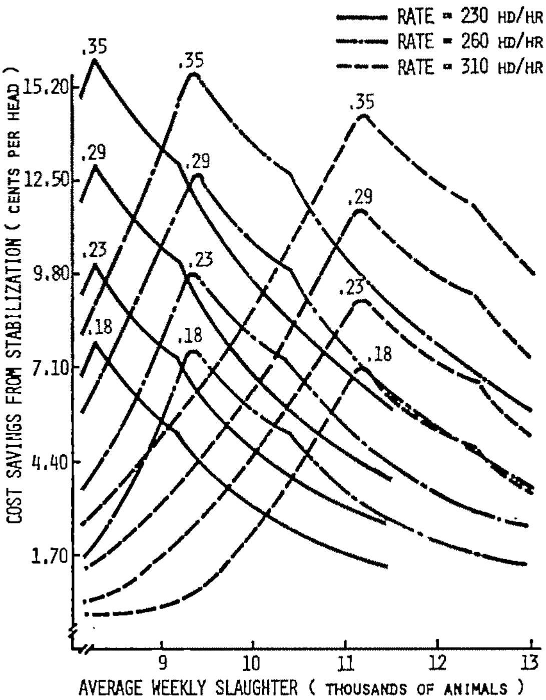

Figure 2. Cost impact of fluctuating slaughter with fixed rates of plant operation

Given this strategy, the in-plant unit cost impact for each rate of fluctuating slaughter versus the same annual volume distributed equally over 52 weeks is shown in Figure 2.

In the figure the horizontal axis shows alternative average weekly slaughter levels for the plant. The cost impact, measured on the vertical axis, is given for different levels of average weekly slaughter, three hourly rates of plant operation, and four levels of slaughter variation. For example, given the constant-hourly-production-rate strategy and an average weekly slaughter of 10,000 head, cost savings from 2.3 to 13.7 cents per head by eliminating supply fluctuations were estimated.

The results in Figure 2 show that, for each rate and level of fluctuation, cost savings from the elimination of supply fluctuations increased, reached a maximum, and then decreased with weekly slaughter. In all instances the peak of the total cost saving function was greatest at the volume corresponding to 36 hours of operation. Since workers were guaranteed a minimum of 36 hours regardless of the hours the plant actually operated, a sharp upward kink in the slope of the total weekly cost function occurred at that point. For a given average weekly slaughter, however, the cost

saving was greatest for the output rate that is the least-cost rate for that level of slaughter, e.g., $r=260$ for 10,000 head per week. As would be expected, the curves also show that the cost savings generally were greater for higher coefficients of variation.

The cost savings for the volumes corresponding to 40-hour work-weeks can easily be indicated. For the 230 hourly rate (average weekly slaughter of 9,200 in Figure 2), the range of cost savings was 5 to 12 cents per head. Thus plants whose variation is larger than the average for the region would be expected to benefit more from lower costs than other plants if slaughter were stabilized. At the 260 rate (average weekly slaughter of 10,400 in Figure 2), the range was 5 to 12.5 cents. If the plant operated at the 310 rate (average weekly slaughter of 12,400 in Figure 2), the range of cost saving from the elimination of supply fluctuations was 4.5 to 11.5 cents per head. Thus the range of savings for a 40-hour work week was about equal for each slaughter rate.

Adjusting slaughter rates on a weekly basis

In the previous section it was assumed that the firm would set the hourly production rate for the entire year and consequently could adjust weekly plant slaughter only by changing hours of operation. As a result the plant was operating off its minimum-average-cost envelope in each week in which the fixed hourly rate was not the least-cost rate for the actual weekly slaughter. An alternative is to permit the firm to make adjustments both in hours of operation *and* hourly production rate, that is, to set the slaughter rate on a weekly basis and operate for as many hours as necessary to slaughter the available livestock.

Under this dual adjustment strategy, if we assume that weekly livestock receipts are stable or can be predicted with error, the firm will choose the hourly slaughter rate each week that minimizes costs for the known volume. As a result the firm always operates on a minimum-cost envelope. Given this strategy and perfect prediction, the cost savings from stabilization could be calculated as in the previous section. The cost impact of stabilization would be smaller, however, since the costs associated with operations off the minimum-average-cost envelope would be eliminated.

To extend our analysis, we wanted to relax the unrealistic assumption that the firm can predict weekly receipts without error and consider the cost impact when actual receipts may diverge from forecasted slaughter so that the selected rate of operation may also be nonoptimal. Assume that the firm forecasts its receipts each week and selects an hourly rate of operation to minimize costs of slaughter for the forecasted volume. Costs under imperfect forecasting may be higher, however, if the firm has to operate at the planned, nonoptimal rate for the entire week, adjusting to actual receipts by altering hours of operation. Consequently, two components of the impact on cost of eliminating slaughter fluctuations can be identified. The first component compares unit costs of stable weekly slaughter with unit costs of variable weekly slaughter and is concerned *only* with operation on the minimum-cost envelope. The second component is the additional slaughter cost arising from imperfect forecasting and the firm's inability to consistently choose the optimal rate; the firm may at times be operating *off* the minimum-cost envelope, which implies a higher unit cost. If the firm's forecasts were always correct, the second component would equal zero.

The firm was assumed to use the current week's actual receipts as its forecast of receipts in the following week.[8] Cost savings from stabilization in this situation are shown in Figure 3. In this figure the cost impact shows the savings from stabilizing weekly slaughter as compared to varying slaughter at a specified level. The pattern in the 8,500–11,000 range of weekly volume is influenced by the tendency for the total variable cost curve to be concave from below in this interval, which lowers gains from stabilization. For some average weekly levels of slaughter, however, the uncertainty component increased the potential gains from stabilization. For example, at a weekly average slaughter of 11,000, the gains ranged from 5.3 cents per head for the lowest level of weekly fluctuation considered to 16.8 cents for the highest.

The cost savings from stabilization shown in Figure 3 are composed jointly of the effect of eliminating supply fluctuations and the effect of eliminating imperfect forecasting. The uncertainty effect is shown separately in Figure 4, where each line shows the gains from stabilization that arose because the rates chosen in some weeks were not the optimal rates for the

[8] Other prediction methods were considered, including a regression equation of the form $s_t=a+b(s_{t-1})$. The results were similar to the simple prediction model presented above.

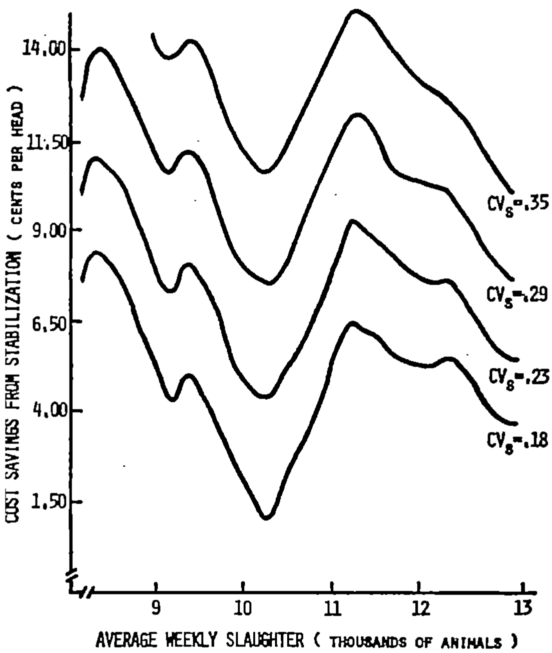

Figure 3. Cost impact of stable versus fluctuating slaughter under imperfect forecast

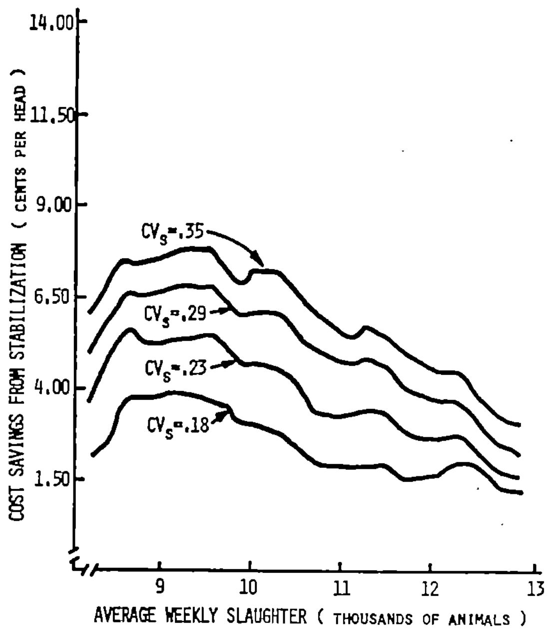

Figure 4. Cost impact of imperfect forecasting

actual level of slaughter in those weeks. The greater the level of variation, the more often the chosen rate was not optimal and hence the larger the savings from stabilization. Also, at a given level of variation the largest cost savings occurred at lower levels of slaughter, since the chosen rate was more often not the minimum-cost rate for the actual volume of receipts. The general nature of these results follows from the logic of the model and the simulation procedure and not the specific weekly slaughter index. The relationships among supply variations, imperfect predictions, and costs reflects the underlying model and is more important than the local ups and downs of the curves in Figure 4.

Model II: Fluctuations and Firm Profits

Model I is consistent with conclusions of previous studies. Week-to-week fluctuations in livestock receipts do result in higher slaughter costs. Cost impacts depend on the nature of the plant cost curves, the possibilities for adjusting rate and hours of operation, and the degree to which the firm can forecast weekly volumes. Larger supply fluctuations, ceteris paribus, lead to higher costs, which suggests that the firm would prefer stable to fluctuating volumes. Such a conclusion, however, should be based on profit impacts and not cost considerations alone. The model presented in this section was developed to determine the impact of fluctuations on profits.

The market conditions facing the firm each week in Model II were (1) density of available livestock supplies, (2) the price of live hogs at the plant, and (3) the wholesale carcass price. The basis for Model II is the firm forecast of its gross margin, i.e., the difference between buying and selling prices expressed in dollars per animal unit. On the basis of this forecast the firm chooses an optimal weekly output, which further implies a choice of a rate-and-hours-of-operation configuration on the cost envelope of the plant. If the forecast is accurate, the planned output is optimal. But if prices have been forecast imperfectly, this output level may be larger or smaller than optimal; consequently a loss of net revenue is suffered in the sense that actual net revenue is lower than it would have been had the optimal output been produced.

A summary of Model II results is given in Table 1. Data sets for 1965, 1966, and 1967 were used to simulate profit impacts on the plant. Each year's data included 52 weekly margins and densities, for which means and coefficients of variation are shown in the last four columns. The $\bar{s}$ volume is the average weekly slaughter chosen by the model, and CV_s is the coefficient of variation of this weekly slaughter.

C is the cost *savings* that would result from

Table 1. Model II: Cost savings and profit reductions from stabilization of slaughter

Data year	Model II results					Exogenous values			
	Cost impact C	Perfect forecasting P	Imperfect forecasting P'	Weekly average slaughter $\bar{s}$	Weekly slaughter CV_s	Margin average	Margin CV	Density average	Density CV
	cents per head					*dollars*			
	3.7	26.2	13.4	13,388	0.24	2.37	0.58	5.0	0.34
1966	3.4	46.1	43.6	12,602	0.29	2.20	0.83	5.0	0.32
1967	4.5	42.2	37.5	12,166	0.32	2.79	0.80	5.0	0.33

stabilization of average weekly slaughter. These impacts are comparable to the results of Model I, although they differ slightly because of the way weekly output is determined.

P is the ***reduction*** in profit per head that would result from stabilization of slaughter at the annual weekly average. This reduction occurs because the stable weekly slaughter would not necessarily be the optimal output for the price and density relationships prevailing in a given week. This profit impact was calculated for both perfect and imperfect forecasting situations.

Perfect forecasting

When price forecasts were perfect, the model chose weekly outputs with annual CV_s's that ranged from .24 to .32. These values exceeded the observed regional slaughter variation, which ranged from .14 to .19 during the three years. Cost savings from stabilization ranged from 3.4 to 4.5 cents per head. The profit reductions, however, ranged from 26 to 46 cents per head. These profit reductions are what the firm could ***gain*** by varying output optimally in response to exogenous market conditions. These gains more than offset any cost savings that arose from stabilization. Therefore, the firm would have little interest in stabilizing slaughter as long as margins continued to vary.

Imperfect forecasting

We then assumed that the firm used the actual margin in week $t-1$ to forecast the margin for week t and optimal output was planned on the basis of this forecast. The cost impact for this situation is the same as for perfect forecasting.[9] The profit impact, however, is potentially different. In the previous case of perfect prediction, the firm producing a stable output was "wrong" in the sense that the stable output was not likely to be the optimal output for the prices prevailing in a given week. In the present case the ***planned*** output may also be "wrong," but because of imperfect forecasting of margins. As a result, while stabilization will still lead to a profit loss, the loss will be smaller than it was in the perfect prediction model. Table 1 shows that the profit impact for imperfect forecasting ranged from 13 to 44 cents per head, a decrease in the profit impact from 3 to 13 cents per head as compared with perfect forecasting. Nevertheless, the profit impact of stabilization remained strongly negative, so the firm would still prefer to vary slaughter even though market conditions could not be forecasted perfectly. Moreover, the better the firm could predict, the stronger would be the profit incentive to vary weekly slaughter and the weaker the incentive to the firm for stabilizing slaughter.

Conclusions and Implications

Our results lead to the conclusion that a firm would probably want to stabilize weekly slaughter for a plant only if the overall industry were stabilized, so that the stable output was also the optimal output for the plant. This conclusion held both for perfect and imperfect forecasting models in our analysis. Although the models used a very naive forecasting method, better forecasts would make the profit reduction of stabilization larger rather than smaller and hence would increase the profit reduction from stabilization.

A number of stabilization methods have been suggested and tried on a limited basis. One involves vertical integration through firm-owned

[9] The firm estimated the margin in week t with the margin in week $t-1$. Consequently, the optimal output for week $t-1$ was produced in week t, optimal output for t was produced in week $t+1$, etc. The output pattern is the same as with perfect forecasting except for a one-week lag. Hence the cost impact of stabilization and coefficient of variation of slaughter for the plant with imperfect forecasting is the same as for perfect forecasting.

feedlots; another involves contracting with producers for future delivery. It is possible that contracting with individual producers could reduce procurement and slaughter costs. To the extent that such cost savings would exceed additional contracting costs, profits would increase. Further, if contracting implies more reliance on a grade-and-yield method of payment, pricing accuracy would be improved and another source of price uncertainty reduced. But even if production were completely integrated by ownership or contract, the firm would still have the problem of deciding its optimal weekly slaughter in response to changing market conditions. For profit maximization, slaughter would have to vary from week to week. In the simulation the optimal variation for the plant always exceeded the actual variation in the region.

Storage can be used to adjust slaughter rates to sales schedules. Since fresh meat cannot be stored for extended periods and retain its original quality, this is a short-period technique. However, firms also have the option of diverting at least some of the fresh meat into processed products which may be stored for a longer period. A more complex model would be required to incorporate storage and product-mix variables into the firm's decision strategy.

The model assumed that adjustments in rates and hours of operation are costless. This generally is not true; to the extent that costs are incurred by changing rates or hours of operation, the measured cost savings from stabilization would be increased accordingly. Further work is needed to determine the nature and extent of adjustment costs in this and other agricultural processing industries.

The model plant was assumed to operate on a single-shift basis when in fact double-shift operation is not uncommon. Adapting the model to double-shift operations would complicate the simulation process but would probably leave the main conclusions unaltered.

Obviously the models presented in this paper do not include all of the relevant decision variables. However, given the models and the simulation procedure, the resulting profit impacts are indicative of the effects of stabilization by an individual firm. Firms, especially firms that can forecast with a high degree of success, are likely to prefer output instability to stability as long as short-term price variations for raw materials and processed products occur in their industry. Moreover, overall industry stabilization may be equally unattractive to profitable firms in an industry if there are no barriers to prevent new entrants from competing away profits in a stabilized situation.

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Returns and Risks of Expanding Pennsylvania Dairy Farms with Different Levels of Equity

H. R. HINMAN AND R. F. HUTTON

An accepted theory of farm firm behavior was incorporated into an abstract computerized simulation model to evaluate the returns and risks involved to Pennsylvania dairy farm firms expanding at different levels of equity. In addition, management efficiency was treated as a parameter to test for interaction of the policies and situations with this characteristic. The base of the analysis was a dairy farm situation having crop yields and production levels approximating that of an efficient Central Pennsylvania farm. The variations and trends in yield, production, and price were intended to approximate those experienced by Pennsylvania farmers during the previous ten years. Under the given environmental and economic assumptions, the results of this study strongly indicated that the payoff for taking the risk of thinning equity below present conventional levels during farm expansion is quite high in most situations.

OVER the last 20 years inflation in the nonfarm economy has increased the prices of items paid for by farmers while changes in the technology of farm production has kept supply at a level that has failed to increase commensurably the prices received by farmers. This combination of circumstances is forcing farmers to enlarge their operations if they are to maintain their relative income position. In most cases the initial move to a larger farming operation also means a decrease in equity due to an increased debt load. In the past, farmers in general have been opposed to positions of low equity and high debt. Their aversion to such situations generally stems from their fear of the uncertainty of future environmental and economic conditions. The purpose of this report is to evaluate, by the use of simulation, the potential returns and risks involved to Pennsylvania dairy farms expanding at different levels of equity under different levels of management efficiency.

The Model

To appraise the effect of alternative financial management practices on a farm organization, an accepted theory of farm firm behavior was incorporated into an abstract computer simulation model. This model permitted expression of variability in crop and livestock production due to natural hazards and other like sources of risk in agriculture. It also permitted variability in product prices and allowed expression of trends in product prices and in asset values over time. Although this study dealt primarily with the Central Pennsylvania dairy farmer, the simulator was designed so that it could be used to research a variety of different farming conditions and organizations. A full description of the features, logic, and instructions for the use of the simulator is contained in [4], and a general description of the model is given in [3].

Initial Situation

A dairy farm situation provided the basis for the analyses. The procedure was to establish a financial equity policy for a particular farm situation and then determine the effects of this policy under postulated changes in management efficiency. The base point for the changes was a situation having crop yields and production levels approximating that of an efficient Central Pennsylvania dairy farmer. The input-output and price coefficients used in this study are available elsewhere [2].

Prices and cost were set in the base situation to approximate those that were prevalent at the time of the analysis. A price trend for milk of 1 percent per year and a land value of 6 percent per year were assumed in the basic situation, and a 3 percent trend was assumed in the cost of capital assets. These trends approximated rates realized in the recent past. The variations in crop and milk yields and in product prices were representative of the variations experienced by farmers in Central Pennsylvania.

The initial size of the firm depended upon its equity policy. The smaller the hypothesized percentage of equity, the larger the beginning farm size and of course the larger the farm debt. In each case it was assumed that the firm's net worth was $37,250, that the beginning inventory of equipment and silos was $14,045, and

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that the farm family supplied 2,500 hours of unpaid labor.

The total possible asset value for the initial farm unit was determined by dividing the equity ratio into the beginning net worth value. From this total value the fixed inventory value of equipment and silos and a cash operating reserve of $3,000 were deducted to give the fund available for investment in other capital.

To establish the base situation for the various equity situations, the fund available for investment was allocated to land, buildings, and dairy animals in a fixed proportion. Because of the fixed characteristics of the allocated assets the actual total asset value was slightly less than the calculated total possible asset value for each equity situation. The initial land acreage, number of cows, and total asset value for the four equity policies explored in this study are given in Table 1.

Table 1. Number of cows, acres of land, and total asset value for beginning dairy farms with a net worth value of $37,250, operating under four equity policies

Equity policy	Total land	Cows	Total assets
percent	*acres*	*head*	*dollars*
40	208	28	93,045
45	176	25	82,170
50	152	23	74,170
60	120	18	62,045

The total debt in the beginning situation was assumed to be 85 percent real estate and 15 percent chattel. The real estate debt had a 20-year and the chattel debt a 5-year repayment period. Both real and chattel debt carried a 7 percent rate of interest. A short-term loan, obtained to cover current expenditures, was paid in full with 6 percent interest at the end of the year.

Decision Rules for Firm Growth

Decision rules for firm growth were developed under the assumption that the operator was interested in expanding his business as fast as possible, subject to the equity constraints and withdrawal demands of the farm family. As the dairy enterprise expanded, enough additional land was rented to provide for 75 percent or more of the needed feed. Any feed not provided by the farm firm was purchased. All situations were simulated over a 10-year period.

The decision function used in this study reflected some measure of preference among competing alternatives. However, a complete preference system was not programmed into the model for two reasons. First, the structure of the relationships existing among the many variables of an individual's preference system is unknown. If all of these relationships were known, they could be programmed into the model and the "best" of all financial policies tested could then be determined. Second, even if a complete preference system were programmed into the model, it would represent an estimate of only one person's preference system. This study was designed to serve many different individuals, each with a unique preference system.

However, a few specific assumptions about an individual's preference system were added to the decision function used in this study. For example, once the business was established, the equity level used in establishing the business served as the equity base in calculating funds available for additional expansion at the beginning of each simulated year. Expansion was made only if funds were available and if expected returns from the investment were above a certain minimum percentage. As the farmer's cash income increased, his minimum expected gross rate of return also increased before he invested in plant and facilities. With cash income of $10,000 or less, the expected gross rate of return had to be 12 percent or more before additional investment in plant and facilities. With cash income of $10,000–$20,000, the expected rate of return had to be 15 percent or more before additional investment. Above $20,000 cash income, the rate of expected return had to be 20 percent or more before investment.[1] The positive relationship between required rate of prospective returns and level of income reflected an increased preference for equity holdings as income expanded.

The equipment and silo usage for the farm operation was calculated each year. Usage not fully provided by inventory was provided by rental or purchase, whichever was most economical.

Actual production was lagged one year behind decisions to expand the dairy enterprise.

[1] The expected gross returns necessary for the farmer to expand was based on the realized gross returns to Pennsylvania dairy farmers reported in [1].

During that year the required expansion in facilities was made, and funds needed to purchase cows for the increase in herd size were held in reserve.

Withdrawals from the firm for family expenditures were made at the end of the year and were based upon the firm's net cash income after taxes but before payment of debt principal. A minimum of $6,000 per year was required for family living expenses; consumption expenditures beyond $6,000 were made a step function of cash income. Fifty percent of the income over $6,000 but less than $10,000 was withdrawn; 30 percent of the income over $10,000 but less than $18,000; and 25 percent of the income over $18,000.[2]

Effect of Equity Policy on Firm Growth

The average equity position of all farmers in the United States in 1968 was 82 percent [6, p. 75]. This study considered four levels of equity below this average. Farm growth was evaluated at equity levels of 40, 45, 50, and 60 percent; and the management efficiency levels under which the growth of the firms operating at these levels were evaluated varied in increments of 5 percent, from 85 to 100 percent of the standard production level.

For each situation evaluated, estimates were obtained for average net worth, average cash operating income, the coefficient of variation associated with net worth, and that associated with cash operating income. These estimates were based upon 25 runs of the model for each situation. A random number generator was used to select the actual variation from the mean yield and prices for each particular run.

The results in Table 2 show that in every situation, except for 60 percent equity and 85 percent management efficiency, the average net worth accumulation (subject to the consumption withdrawals described above) increased over the 10-year period. However, only those policies having 50 percent or less equity operating at the high levels of management efficiency resulted in an average growth equal to or greater than the initial investment compounded at 7 percent over a 10-year period. The initial investment of $37,250 compounded at 7 percent for 10 years results in a value of $73,250.

For all equity policies considered, the appreciation in land values (6 percent) played a significant role in the ending value of net worth regardless of the management efficiency level. As previously mentioned, the lower the beginning equity the larger the beginning farm size. As a result, the farms following the policies of low equity benefited the most from land appreciation.

As expected, the less efficient operations expanded at a much slower rate than the efficient operations. For the 40 percent equity policy, operating at standard production efficiency, the average herd size increased from 28 to 115 cows over a 10-year period. Under the same equity policy operating at 95 percent standard production efficiency, the average

[2] The consumption function was derived subjectively with insight obtained from [5].

Table 2. Summary of changes and variations in net worth and cash operating income for simulated Pennsylvania dairy farm firms operating under different equity and management efficiency levels over a 10-year period

Percent equity policy	Percent management efficiency level	Average net worth at end of year 1 ($1000)	Coefficient of variation of net worth at end of year 1	Average net worth at end of year 10 ($1000)	Coefficient of variation of net worth at end of year 10	Average cash operating income in year 1 ($1000)	Coefficient of variation of cash operating income in year 1	Average cash operating income in year 10 ($1000)	Coefficient of variation of cash operating income in year 10
40	100	41.5	.034	111.0	.124	11.4	.261	19.2	.562
40	95	40.7	.031	88.8	.114	9.8	.282	11.6	.612
40	90	39.8	.033	71.2	.103	8.0	.326	6.7	.622
40	85	38.7	.041	56.8	.115	6.2	.396	3.8	.723
45	100	40.6	.029	95.7	.139	10.6	.240	15.8	.470
45	95	39.9	.027	76.8	.090	9.2	.263	10.3	.457
45	90	39.1	.030	63.4	.086	7.7	.300	7.2	.413
45	85	38.2	.037	53.0	.110	6.1	.356	4.6	.498
50	100	39.8	.026	82.1	.096	9.9	.233	13.8	.363
50	95	39.2	.025	66.9	.088	8.5	.257	9.3	.362
50	90	38.5	.029	57.8	.086	7.2	.292	6.9	.389
50	85	37.6	.036	48.1	.129	5.8	.342	4.7	.479
60	100	38.6	.021	60.7	.077	8.1	.223	9.7	.233
60	95	38.0	.024	53.0	.086	7.0	.245	7.4	.242
60	90	37.3	.029	45.2	.108	5.9	.276	5.7	.310
60	85	36.5	.034	34.9	.158	4.9	.320	3.7	.454

herd size increased only to 75 cows in the same period. At 90 and 85 percent of standard efficiency of production the average ending herd sizes under the 40 percent equity policy were 55 and 34, respectively.

Comparison of figures in Table 2 illustrates a strong interaction of management efficiency with equity policy. For example, the 85 percent efficiency level for the 40 percent equity policy resulted in an average net worth greater than that realized by the 60 percent equity policy operating at an efficiency level of 95 percent.

The variations in net worth increased only slightly as the equity fell for those firms operating at the higher production efficiency levels. However, below 95 percent of standard efficiency there was no variation in net worth that could be attributed to the difference in equity policies. This was the case because at the lower levels of efficiency practically all cash generated by the firm was used for family expenditures. Growth in net worth at the lower levels of efficiency depended primarily upon the appreciation of land values.

For each of the equity policies examined the average cash operating income decreased over the 10-year period for all situations operating at less than 95 percent efficiency. Also, the variation in the cash operating income of the firm increased as the percent equity decreased and, within each equity policy, as the management efficiency level decreased. In other words, as firms operated at lower and lower levels of equity, the risk of an unstable income increased. Furthermore, as the level of management efficiency decreased, the risk of an unstable cash income further increased.

Summary and Conclusions

Considering all aspects associated with given equity policies it seems likely that many farmers, if given the chance and information on the alternatives, would move towards lower than conventional equity levels in expanding their businesses. For all equity policies and management efficiency levels evaluated, in only one case—that of 60 percent equity and 85 percent management efficiency—did the average net worth decrease over the 10-year period; in all other situations there was an increase in the average net worth. Average cash operating income, on the other hand, decreased over the 10-year period for all equity policies operating below the 95 percent management efficiency level. Furthermore, as the efficiency level decreased, the variation of cash income increased, indicating not only less average income but also a less stable income.

Variations in net worth were only slightly responsive to equity level or management efficiency level. Variations in cash operating income, on the other hand, not only increased as the management efficiency level decreased but also increased as the equity level decreased. In other words, as the equity level and/or management efficiency level decreased, the risk of an unstable cash income increased. The main reason for a relatively stable increase in net worth was the stabilizing effect of the 6 percent land appreciation factor. If a firm owns no land or other large capital items that appreciate over the years, the likely variation in net worth that it will experience would be larger and more responsive to both the equity and management efficiency levels.

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Linear Programming Approximation of Least-Cost Feed Mixes with Probability Restrictions*

SABIR A. RAHMAN AND F. E. BENDER

This article presents a method for solving linear programming problems in which elements of the tableau are stochastic. Using least-cost poultry rations as an example, the authors demonstrate the procedure developed. Sufficiently accurate results are obtained with less time and complexity than required by alternative methods. The authors conclude that the largest obstacle to examining related problems is in the limitations imposed by lack of data, in this case with regard to biological minima.

QUITE often a researcher faces a situation in which the usual assumptions of linear programming do not hold. An example is provided by the least-cost feed mix problem where the assumption that the input-output coefficients (a_{ij}) are known and constant is not valid. In the regular linear programming formulation of this problem the estimates of population means of nutrient contents, derived from numerous samples of feedstuffs (e.g., soybean, corn, alfalfa), are used as a_{ij}'s. These a_{ij} values are then the estimates of population means describing the percent protein, fat, fiber, etc. content of each potential ingredient for the final mix. Once estimated, these coefficients are rarely changed even though some variability among samples is known to exist. Recognition may be given to certain types of variability by using different coefficients for an "old" and a "new" crop of some ingredient, but the variability within the crop is ignored.

Given a finite number of samples of a feed ingredient, some variability among the results of the analyses for the various nutrient components is expected. If this variability is ignored, as commonly is done in solving a least-cost feed mix problem using the regular linear programming formulation [6, p. 131], the solution on the average will meet the requirements only 50 percent of the time.[1] Meeting the requirements at a higher confidence level can be achieved only if the variability among sample means, as measured by the variance, can be accounted for.

Since the variance equation is nonlinear, any formulation of this problem that contains the variance equation necessarily requires a nonlinear algorithm for its solution, e.g., [7, 10, 11, 12]. But such algorithms are not as common and easy to use as a linear program. Thus it becomes highly desirable to reduce the problem to a linear programming framework. A linearization of the variance equation is required to accomplish this transformation.

The purpose of this paper is to derive a linear approximation of the variance equation capable of incorporation into the linear programming formulation of the least-cost feed mix problem in order to raise the probability of meeting the requirements from the conventional 50 percent level to a desired higher level.

The plan of this paper is as follows:

1. The conventional linear programming formulation of the least-cost feed mix problem is presented and its stochastic elements are identified.
2. The statistical properties of a linear function are discussed and the expressions for mean and variance are derived.
3. A survey is made of methods presently available to solve this problem.
4. Two methods of linearization of the variance expression are presented, namely, the Taylor Series approximation and a direct approximation.
5. The direct approximation is chosen for use in the preparation of the stochastic tableau.

The objective is to prepare a broiler ration that contains a minimum of 24 percent protein at least 80 percent of the time. The data used were collected from the Delmarva[2] area. The

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[1] Throughout this paper it will be assumed that the distributions with which we are concerned are normal distributions. Since we are dealing primarily with means of samples, the assumption of normality is a reasonable one.

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[2] The data were provided by Hugh Nott and G. F. Combs of the Poultry Science Department, University of Mary-

results and a summary of the work are presented in the final two sections of the paper.

Standard Linear Programming Model

A standard linear programming problem, in matrix form, may be stated as follows:

$$\begin{array}{ll} \text{Optimize} & Z = C'X \\ \text{subject to} & AX \geq B \\ \text{and} & X \geq 0 \end{array}$$

Conventionally, the elements of C, A, and B are all assumed to be known and constant in solving the problem by a linear program [1, 5, 6]. However, this assumption is not valid for least-cost feed mix problems in which one or more rows of A and corresponding elements of B may be stochastic.

Statistical Properties of a Linear Function

Since all the constraints involved in the problem are linear, one must examine the statistical properties of a linear function in order to account for the stochastic nature of the input-output coefficients.

Let the ith row of A contain stochastic elements. This row can, without any loss of generality, be assumed to be the protein row; the protein constraint can then be written as

$$(1) \quad a_{i1}x_1 + a_{i2}x_2 + \cdots + a_{in}x_n \geq b_i$$

where

b_i = the required level of protein (ith nutrient);

a_{ij} = the percentage of protein supplied by a unit of the jth ingredient (e.g., corn);

x_j = the unknown quantity of the jth ingredient to be used in a unit of the final mix.

For the sake of convenience, the inequality (1) can be regarded as an equation and written as

$$b_i^* = a_{i1}x_1 + a_{i2}x_2 + \cdots + a_{in}x_n = \sum_j a_{ij}x_j$$

This is a linear function in which b_i and the a_{ij}'s are stochastic, but the x_j's are deterministic. Observing that x_j and a_{ij} are not related, the statistical properties, i.e., the mean and the variance, of this linear function can be summarized as follows:[3]

Mean

$$(2) \quad \mu_{b_i} = E(b_i) = \sum_j x_j E(a_{ij}) = \sum_j x_j \mu_{ij}$$

Variance

$$(3) \quad \sigma_{b_i}^2 = E[\{b_i - E(b_i)\}^2] = \sum_j \sigma_{ij}^2 x_j^2 + \sum_j \sum_{\substack{k \\ j \neq k}} \sigma_{ij,k} x_j x_k$$

where

μ_{b_i} = the mean content of the ith nutrient (i.e., protein) in the final mix;

μ_{ij} = the mean content of ith nutrient (protein) in the jth ingredient;

$\sigma_{b_i}^2$ = the variance of the ith nutrient level (protein) in the final mix;

σ_{ij}^2 = the variance of the ith nutrient (protein) contained in the jth ingredient;

$\sigma_{ij,k}$ = the covariance between the jth and the kth ingredients in their respective levels of ith nutrient (protein).

It may be observed here that the nutrient contents of the ingredients are not interdependent; the protein content of corn is not influenced by the protein content of soybean. Therefore the covariance must be zero. The second term in equation (3) drops out, reducing the equation to

$$(4) \quad \sigma_{b_i}^2 = \sum_j \sigma_{ij}^2 x_j^2$$

This is the quadratic expression for the variance of protein level in the final mix.

Alternative Methods of Solution

The regular linear programming formulation implicitly assumes the property expressed in equation (2). That is, the mean of the final mix is equal to the weighted means of the ingredients. Considering the a_{ij}'s to be known constants, the problem is solved accordingly. However, since the a_{ij}'s are not necessarily known constants, the probability of meeting the re-

land, with kind permission for their use in this research. The data used in this research were only a part of their data which appear in [4].

[3] These properties are discussed in most textbooks on mathematical statistics. For example, see Anderson and Bancroft [2, pp. 63–64].

quirements through such a formulation, as mentioned earlier, is only 50 percent.

Van de Panne and Popp [10] have improved the formulation, hence the probability of meeting the requirements, by adding equation (4) as an additional constraint. The incorporation of equation (4) into the feed mix formulation results in a modified protein row that is a function of the standard deviation of the final mix and the objective function. The net effect of such modification is to increase the mean of the final mix as a function of its standard deviation. This procedure requires a nonlinear algorithm based on Zoutendijk's methods [11, 12].

Stochastic linear programming, as presented by Johnson et al. [8], uses the Distribution Method. However, the large number of solutions required to approximate the distribution of results makes the procedure impractical for feed mix problems which must be formulated at frequent intervals (as often as weekly in integrated broiler firms).

Nott and Combs [9, 4] propose a method in which each a_{ij} is adjusted downward by a fraction of its own standard deviation, thus raising the actual nutrient level above the required level. For protein they decreased the a_{ij} by one-half and one standard deviation respectively. Such adjustments resulted in solutions that were above the minimum required level 88 to 92 percent and 96 to 98 percent of the time, respectively [9].

Linear Approximation of Variance Equation

In order to account for the variability of nutrient content and still use commonly available linear programming algorithms, equation (4) must be linearized. There are various methods of deriving a linear approximation for equation (4), but only two are discussed here. The first is based on a Taylor Series expansion of σ_{b_i}; the second is a direct approximation. These two approximations will now be derived and compared with each other to provide a foundation for choice of the one to be used in this research.

Taylor Series approximation

Equation (4) can be written as

$$\sigma_{b_i} = \left[\sum_j \sigma_{ij}^2 x_j^2 \right]^{1/2}$$

The right-hand side of this equation can be expanded through a Taylor Series expansion at the point

$$x_j = x_j^0 \quad \text{for } j = 1, 2, \cdots, n$$

In the neighborhood of this point the terms of second and higher order in the expansion can be ignored, to yield the following:

$$\sigma_{b_i} = \left[\sum_j \frac{\sigma_{ij}^2 x_j^0}{\left\{ \sum_j \sigma_{ij}^2 x_j^{0^2} \right\}^{1/2}} \right] x_j$$

or

$$\sigma_{b_i} = \sum_j \delta_{ij} x_j \tag{5}$$

where

$$\delta_{ij} = \frac{\sigma_{ij}^2 x_j^0}{\left\{ \sum_j \sigma_{ij}^2 x_j^{0^2} \right\}^{1/2}}$$

Provided that the solution is sufficiently close to the point at which the expansion has been carried out, equation (5) provides a reasonably good linear approximation to equation (4).

Direct approximation

In order to obtain a direct linear approximation of equation (4), consider the following relation:

$$\sigma_{b_i}^* = \sum_j \sigma_{ij} x_j \tag{6}$$

By squaring both sides, we obtain

$$\sigma_{b_i}^{*^2} = \sum_j \sigma_{ij}^2 x_j^2 + \sum_{\substack{j \\ j \neq k}} \sum_k \sigma_{ij} \sigma_{ik} x_j x_k$$

and

$$\sigma_{b_i}^{*^2} = \sigma_{b_i}^2 + \sum_{\substack{j \\ j \neq k}} \sum_k \sigma_{ij} \sigma_{ik} x_j x_k$$

This differs from equation (4) by the second term, which (being a sum of positive cross-products) is positive. Therefore,

$$\sigma_{b_i}^{*^2} \geq \sigma_{b_i}^2 \tag{7}$$

If σ_{b_i} is approximated by $\sigma_{b_i}^*$, the result, as a consequence of relation (7), would be biased. However, the bias is in a known direction, as

shown by relation (7). The practical consequence of this bias is that the actual probability of meeting the requirements would generally be more than the specified value; in no case would it be less than the specified value. Equation (6) is therefore an acceptable linear approximation for the purpose of this study.

Choice of approximation

Equation (5) is a linear approximation of equation (4) derived through a Taylor Series expansion. In order to use this approximation, one would require: (i) an estimate of the results before the solution can be started;[4] (ii) additional programming effort to compute δ_{ij} for each successive solution. The approximation contained in equation (6), on the other hand, avoids these complications. It requires neither any estimate of the results beforehand nor any additional programming effort.

However, both are approximations of the exact equation, and any solution obtained by using them has to be iterated to obtain the desired results. Since the relative merits of the two approximations in the matter of accuracy are not precisely known, the choice between them must be based on relative simplicity and ease of application. The approximation of equation (6) was chosen for this research because it met these criteria.

[4] A Taylor Series is a polynomial expansion of a function at a given point. Taylor Series expansion of $f(x_1, x_2, \cdots, x_n)$, a function of n variables, at the point $x_j = x_j^0$ for $j = 1, 2, \cdots, n$ is as follows:

$$f(x_1, x_2, \cdots, x_n) = f(x_1^0, x_2^0, \cdots, x_n^0) + \sum_j (x_j - x_j^0) \frac{\partial f}{\partial x_j}\bigg|_{x_j = x_j^0} + \frac{1}{2!} \sum_j (x_j - x_j^0)^2 \frac{\partial^2 f}{\partial x_j^2}\bigg|_{x = x^0} + \cdots$$

Our linear program seeks to determine the values of x_j's. The series is a polynomial in $(x_j - x_j^0)$, where (x_j^0) is the fixed point. If the x_j's determined by the linear program are sufficiently close to the x_j^0's, the difference, $(x_j - x_j^0)$, will converge to zero as it is raised to second and higher powers, and the series will converge fast enough to justify an approximation with only the first two terms. If the x_j's are not sufficiently close to the x_j^0's, the series may not converge fast enough or may even diverge.

Taylor Series are discussed in most standard textbooks on mathematical analysis, e.g., [3, p. 417].

Stochastic Linear Programming Model

To raise the probability of meeting the requirement of any nutrient level in the final mix, the requirement level of that nutrient must be modified as a function of its standard deviation in the final mix. This standard deviation must be computed within the solution, for which purpose additional constraints need to be included in the Simplex tableau. Van de Panne and Popp computed the standard deviation of the protein level in the final mix through the following additional constraint:

$$[\sigma_{i1}^2 x_1^2 + \sigma_{i2}^2 x_2^2 + \cdots + \sigma_{in}^2 x_n^2]^{1/2} = x_{n+1}$$

Equation (6), which is a linear approximation of the above constraint, is used in this paper:

$$(6) \qquad \sigma_{i1} x_1 + \sigma_{i2} x_2 + \cdots + \sigma_{in} x_n = x_{n+1}$$

where

x_{n+1} = the standard deviation (σ_i) of protein

Table 1. Tableau for least-cost poultry ration with probability constraint for protein

C_j	131	72	75	80	87.50	77	66	39	108	0		
	Activities											
Activity names	Menhaden fish meal	48 percent meat and bone meal	50 percent meat and bone meal	55 percent meat scraps	Poultry by-products	50 percent soybean meal	20 percent alfalfa	Yellow corn	Corn gluten meal	Protein standard deviation 80 percent normal deviate	Constraint	Activity level
Protein	62.33	47.66	49.92	54.22	63.09	50.08	21.02	9.44	63.56	−.85	≥	24
Protein standard deviation	1.18	1.11	2.30	1.54	2.31	.72	1.04	.53	1.86	−1	=	0
Fat	11.80	9.77	10.29	11.60	13.88	1.26	4.10	4.04	2.28	0	≥	2
Fiber	0	0	0	0	0	3.02	19.88	2.58	1.33	0	≤	3
Weight	1	1	1	1	1	1	1	1	1	0	=	1

level in the final mix. (Since σ_i is unknown it has been added as an additional variable, which is computed within the solution along with the other x_j's.)

The standard deviation computed in equation (6) is used to modify the requirement level of protein as follows:

$$\mu_{i1}x_1 + \mu_{i2}x_2 + \cdots + \mu_{in}x_n \geq b_i + dx_{n+1}$$

where

d = the standard normal deviate, the value of which is dependent on the desired probability of success.

The introduction of the standard deviation equation and the consequent modification of the protein constraint expand the standard tableau by a row and a column. This expanded stochastic tableau is given in Table 1, where $d = 0.85$ for the standard deviation activity. As an ingredient is brought into the basis, the equality of the "standard deviation row" can be maintained only by bringing in the "standard deviation activity." This raises the mean protein level above the specified level, thereby increasing the probability of meeting the requirement. This displacement of the mean is shown in Figure 1.

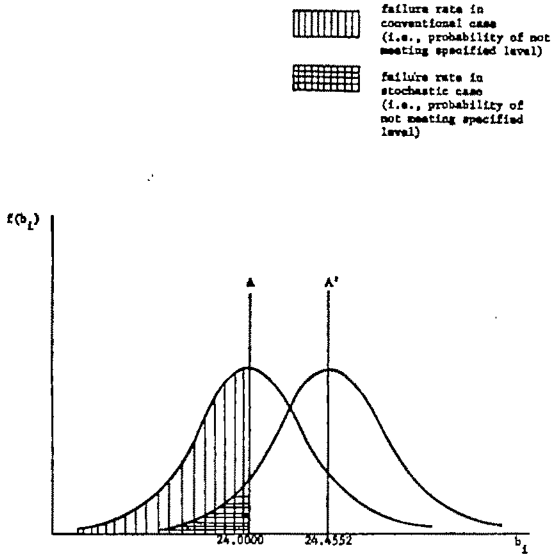

Figure 1. Illustration of the purpose of the standard deviation column and row in the stochastic linear programming tableau (Table 1)

Results

Table 2 summarizes the results of a number of solutions obtained by four different methods:

(i) Regular linear program (models 1 and 2)
(ii) Nott-Combs method (models 3, 4, and 5)
(iii) Method of this paper, called stochastic linear programming (models 6 and 7)
(iv) Exact calculation based on the work of Van de Panne and Popp (model 8)

The regular solution (model 1) exceeds the minimum requirement level of protein only 50 percent of the time, as expected. The Nott-Combs solutions (models 3 and 4) exceed the desired minimum a greater percentage of the time, but not as often as implied by Nott and Combs [9]. Model 3 reduces the a_{ij}'s by one standard deviation to give a probability of success of 91.8 percent, compared with their estimate of 96 to 98 percent. Model 4, which uses one-half standard deviation, gives a probability of success of 75.5 percent, compared with their estimate of 88 to 92 percent.

Model 6 is the first solution of the stochastic method. The value $d = 0.85$ is chosen because it is the 80 percent normal deviate. However, this solution gives a much higher probability of success because of the cross-product terms. It also has a higher associated cost. This probability of success can be lowered to the specified value of 80 percent, and the associated cost reduced, by lowering the value of 'd' to $d = 0.6007$ (model 7).

Model 8 is the result of the exact calculation using the procedure illustrated by Van de Panne and Popp. In this instance the results are identical with those of the approximation presented in this paper. The exact calculation is a modification of a Taylor Series expansion that is very time consuming. Moreover, Van de Panne and Popp indicate that the procedure does not always converge upon a solution, but may actually diverge.

Using row operations on the tableau shown in Table 1, it can be demonstrated that the Nott-Combs procedure and the one presented in this article are mathematically identical. However, the procedure illustrated in this article is easier to implement, and the form of its approximation is more readily apparent. The results of model 5, which are identical with those of model 7, are a reflection of the underlying mathematical equivalence.

Table 2. Summary and comparison of results

Method of solution	Value of parameter	Model	Specified level of protein	Cost per ton	Characteristics of the final mix			
					Level of protein		Probability of success	Probability of failure
					Mean	Standard deviation		
			percent	*dollars*	*percent*			
Regular		1	24.0000	51.5714	23.9999	0.5351	50.0	50.0
		2	24.0000	51.9645	24.4552	0.5419	80.0	20.0
Nott-Combs method	Mean minus one standard deviation	3	24.0000	52.2298	24.7625	0.5467	91.8	8.2
	Mean minus one-half standard deviation	4	24.0000	51.8937	24.3724	0.5405	75.5	24.5
	Mean minus 0.6007 standard deviation	5	24.0000	51.9645	24.4552	0.5419	80.0	20.0
Rahman-Bender approximation method	$d=0.8500$	6	24.0000	52.1298	24.6469	0.5449	88.2	11.8
	$d=0.6007$	7	24.0000	51.9645	24.4552	0.5419	80.0	20.0
Van de Panne-Popp method		8	24.0000	51.9645	24.4552	0.5419	80.0	20.0

As a check, the authors reran the regular linear programming problem with the mean increased to 24.4552 (i.e., the same mean generated by the stochastic models). As can be seen in Table 2, this results in a solution identical with those of Models 5, 7, and 8. In this simple situation one could have displaced the mean and achieved the same result as the methods that utilized the variance information. However, with greater variation among the variances and a larger, more complex problem this relationship would not continue to hold.

Summary

The least-cost feed-mix problem, commonly solved by a linear program, dictates that the regular linear program be modified to account for the stochastic variability in some of the input-output coefficients. In order to keep the solution within the linear programming framework, this modification necessarily involves a linear approximation of the quadratic variance equation. Such an approximation can either be constructed directly or through a Taylor Series expansion. The direct approximation appears to be preferable because it is easy to use and does not require any advance estimate of the results.

The results obtained through a modified linear program are quite satisfactory. Although the method is an approximate one, desired results can be obtained through iteration of the solution by trial and error.

A shortcoming of this work is a lack of knowledge about the correct level of protein and probability of failure. Twenty-four percent protein and a failure rate of 20 percent were used because the nutritionists concerned with the problem have been using these values.[5] It seems reasonable that past levels of nutrition requirements were established to provide a built-in cushion. In other words, a protein level of 24 percent might be standard because the needed value is 22 percent 90 percent of the time.

Now it is desirable that research in nutrition should begin to examine the respective nutrition requirements in terms of the probability of meeting these requirements, in order to determine the appropriate requirement levels to be used in stochastic linear programming solutions of least-cost feedmix problems.

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Personality Characteristics and Successful Use of Credit by Farm Families*

Kenneth R. Krause and Paul L. Williams

Farm financial management and the use of credit are becoming more important; resource suppliers, including lenders, are seeking ways to better identify and appraise farm operators' and entrepreneurs' potential to successfully use farming resources and credit. A behavioral model that included motivation, ability, and biographic variables was tested on a group of South Dakota farm borrowers and their wives. The selected behavioral-personality variables are described and were related to change in financial position. The strongest results were obtained by including personality measures of both husbands and wives and suggest that personality variables can be developed for use in evaluation of farm credit applications.

As farming grows more capital intensive, good financial management becomes more crucial to success. Among other things, farmers need to become more sophisticated users of borrowed funds. But lenders also should become increasingly sophisticated in their analysis of credit worthiness of potential farm borrowers. It is no longer sufficient for lenders to base their loan decisions on "security" or family name. An increasing number of decisions must be based on projected productivity of the loan itself, as well as on the likelihood that the farmer will successfully manage the borrowed funds.

The inadequacy of present lending criteria is suggested by FHA (Farmers Home Administration) and PCA (Production Credit Association) data from South Dakota for 1960–1964. Approximately two-thirds of the FHA farm operating and real estate loan borrowers in three counties and about one-third of the PCA borrowers in seven counties were unable to repay their loans on schedule or to improve their financial position [5, pp. 10–20].

To what extent is the successful use of credit related to a farmer's personal characteristics and to those of his family members? Can knowledge of these characteristics help lenders "pick" and advise their borrowers more effectively? Can agencies such as FHA use knowledge of these relationships to establish criteria for selecting borrowers? This article reports the results of a study addressed to such questions.

In 1966 the authors conducted a study of successful and unsuccessful FHA and PCA borrowers in South Dakota. Its general purpose was to test conceptual models of the relationships between human behavioral variables and financial success of farm firms.

A Conceptual Model

The general behavioral model of a farm operator-manager used in the study of South Dakota farm borrowers was introduced by Nielson [4, p. 6; 6]. Parts of the model were used in North Central Regional Project 59. Compared with previous applications of the model, the South Dakota effort involved more variables and the close cooperation of a psychologist.

The model assumes that the manager or the managerial complex is a behavioral entity which, like a catalytic agent, does not in and of itself become a part of the product. The model describes a manager as possessing experiences (which Nielson calls biography), motivations, and capabilities. These produce managerial behavior which in turn produces an outcome. The model is completed by appropriate "feedback" from new experience and outcomes. For some types of decisions, the feedback is instantaneous; for others, several similar experiences may be required.

In its application to South Dakota farm borrowers, the model was used specifically for two purposes: (1) to develop hypotheses about and measurements of personality characteristics associated with borrowers' financial success; (2) to develop an "index of potential financial success" for borrowers that lenders could use.

* Opinions expressed in this paper are the authors' and do not necessarily represent the views of the U. S. Department of Agriculture. The analysis is based upon work under South Dakota Experiment Station project 435. Helpful comments on this paper were received from its reviewers and the editors of AJAE.

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The Study

Seventy-two farm couples were interviewed. Their farms were considered to be family-size since labor and management were provided mostly by the family. Included were 32 PCA members and 20 FHA borrowers whose net worth had increased from 1960 through 1964 and 20 FHA borrowers whose net worth had decreased during that period. The 52 borrowers with a net worth increase were always current in payment; the 20 borrowers who showed a decrease in net worth were consistently behind.

The PCA borrowers were the largest and most successful farm operators in their association. The FHA borrowers were a representative cross section of all borrowers in one FHA county office. The range in net worth for the 72 respondents in 1960 was from approximately $7,000 to $45,000, and the value of physical assets ranged from $25,000 to $200,000.

Selection and quantification of variables

Criterion variable.—Change in net worth was used as a measure of financial success. If an increase in net worth occurs, the lender should find his contract fulfilled. Sufficient cash flow may not be generated to meet credit contracts, but lenders may nevertheless renegotiate credit contracts if the borrower's increase in net worth is sufficient to meet lender's security needs. The variable was quantified by using the percent change in net worth from 1960 to 1964.

Personality variables.—Subsamples of successful and unsuccessful managers (husbands and wives) were interviewed in depth in group settings prior to selecting and developing variables related to effective use of credit. Scales from farm and industry managerial evaluation studies were considered where appropriate, and new variables were developed where relevant variables were not available from other sources.[1] All variables were given equal consideration. The authors have published elsewhere a more detailed discussion of the rationale for use and source of previously used variables and development of new variables [5, pp. 30–39].

The following definitional interpretations provide a reference source for the variables used in the South Dakota study.

Motivation: A variable is motivational if it organizes and/or directs a person's behavior. Goal objects may possess either a positive or negative valence; e.g., a farmer may be motivated toward a goal for income or prestige or he may be conversely motivated to avoid anxiety created by debt, nagging of a spouse, or fear of failure.

The following motivation scales (variables) used in the South Dakota study with both men and women have been used in other studies:

1. Risk aversion (reluctance to accept various types and degrees of risk) [2].
2. Scientific orientation (economic orientation toward the scientific method and scientific criteria in decision-making) [2].
3. Authoritarianism (lack of flexibility in attitudes, need for structure in daily activity, and reliance on but at the same time resentment of authority figures) [1].
4. Manifest anxiety (manifestation of symptoms typically associated with anxiety. Three scales were used: manifest anxiety and L and K anxiety scales. The L and K scales partially mask and temper the impact of the anxiety scale questions. The L scale indicates that honest people respond in a predictable manner; the *K* variable reflects a respondent's attitudes toward answering the questions included in the anxiety scale.) [9].
5. External-internal orientation (the degree to which an individual feels that he "controls his own destiny" versus the degree that he feels he is a "victim of fate") [3].
6. Vocational interest (degree of interest in various occupations that are similar to subcategories of operating and managing a farm, e.g., banker, buyer. Scales for 38 vocations were used. A "gross significant vocational interest scale" was developed.) [5, 8].
7. Economic motivation (motivation for achievement of various levels of economic performance) [2].[2]

[1] The behavioral variables were selected and developed under the guidance of co-author Williams, while he was head of the Department of Psychology at South Dakota State University. Hypotheses about husbands' and wives' roles in farm management success were developed from Williams' counseling experience in outpatient mental health centers in rural areas and University and industrial firm counseling centers. With the exception of the industrial firms where supervisors and middle management personnel were counseled, the counseling work was with farmers and farm families and rural residents.

[2] This variable did not enter the final equation for men and women but entered a final equation for either men alone or for women alone. (Hereafter all variables with this limitation will be marked with an asterisk.)

8. Independence (willingness to deviate from neighborhood norms in making management decisions) [2].*

Ability: A positive relationship between ability and farm success was assumed. The relationship is tempered by biographical and motivational factors in the human complex.

The first, third, and fourth of the following ability scales (variables) were all previously found to be statistically significant. The second variable was developed during the course of the study, and all four were used for both men and women.

1. Adaptability (basic mental problem solving ability) [10].
2. Knowledge of scientific animal production facts (ability to recognize scientific facts associated with farming) [5].
3. Abstracting (ability to absorb, theorize, and visualize facts, ideas, and notions) [7].*
4. Figures (ability to solve various types of arithmetic problems) [7].*

Biography: Biography refers to a history of a person's experience and is conditioned by such factors as education, geographic location, and occupation. An individual's biography influences what he knows and how he thinks, acts, and reacts to a set of sets or stimuli. New experience may change or add to the composition of an individual's biography.

All of the biographic variables were developed and named during the course of the study and are available from the authors [5]. Naming of a variable is at best a tenuous art. Separate biographic variables were developed for men and for women:

Men's variables

1. Aggressive conservatism (tendency to moderately challenge existing farm practices and agricultural institutions).
2. External farm and financial help (expectations of physical and managerial help from parents, relatives, and neighbors and credit from all sources).*
3. Farm growth objectives (physical and business growth strategies for the farm firm).*
4. Life expectations (economic, social, and personal objectives).*
5. Socioeconomic status (relative economic and social standing of the farm business and the farm family in the farm and agribusiness community).*
6. Farm independence (independence of the farm firm from external forces).*

Women's variables

1. Unresolved rebellion (disagreement with present personal situations in relation to lifetime goals).
2. Life aspirations (personal, real, and imagined goals).*
3. Submissiveness (willingness to submit to external forces to attain personal goals).*
4. Rebellion toward parental negativeness (disagreement with parental upbringing and current parental assistance).*
5. Social and economic outlook (social and economic attitude and perspective on life).*
6. Financial knowledge (the role of net income and investment in the farm business).*

A numerical score was determined for each respondent for each variable. Depending upon the questions, the score was determined, for instance, by the number right or wrong or by the weights that respondents assigned to all of the questions that were used for a variable. Biography variables were developed by using highly structured questions involving specific experiences or "feelings." A centroid factor analysis technique was used to develop a scale by grouping questions. The score of each respondent on each variable was entered in a regression model.

Results

In addition to selection of independent and criterion variables, we had to decide whether to include only men or couples. Given no a priori knowledge of whether men alone would provide as strong a predictor of success as couples, both were included in the analysis as follows: (1) men's behavioral components alone; (2) women's behavioral components alone; (3) both men's and women's behavioral components. All previously used and new independent variables that were developed for the study were considered in each model. The purpose of the models was to relate human behavioral variables to financial success in farm firms.

Past farm and industrial managerial evaluation studies have shown that there is considerable interaction among independent variables

of the type considered in the South Dakota study. While the statistical results indicated lower interaction than in most previous studies, several variables were eliminated on the basis of low correlation with the dependent variable and high correlation with one or more independent variables. Each variable was considered in a final equation if its F level was significant at the 10 percent level and if it was not significantly correlated with another independent variable. When two independent variables were correlated at a significant level, the variable with the higher simple correlation with the dependent variable was entered in the final equation.

The management entity appeared to be more completely measured when men's and women's independent variables both were considered in an equation than when either men or women alone were considered. The matrix of simple correlation coefficients for couples is presented in Table 1. Very few of the variables showed significant intercorrelation, and where they showed a statistically significant relationship the level was relatively low; the simple correlation coefficient (r) was less than .4. Three pairs of independent variables showed significant correlation at the .3 or above level: "external-internal orientation" and "L anxiety"; "aggressive conservatism" and "gross significant vocational interest score"; and "unresolved rebellion" and a "vocational interest-banker" variable. Individual variables in the pairs that showed significant relationship with the dependent variables were "external-internal orientation," "aggressive conservatism," "gross significant vocational interest," and "unresolved rebellion."

Only 6 of the 13 independent variables showed significant correlation with the dependent variable, "change in net worth." Seven variables without significant correlation with the dependent variable were left in the final equation since (1) they logically explained important parts of the model or (2) they were not significantly correlated with other variables, and (3) they were significantly different from zero at a 10 percent level of significance or less.

Table 2 shows the "b" values, F ratio, and mathematical form of each independent variable. With an objective of developing a prediction equation with the highest R^2, the various independent variables could enter the final equation in either linear, log, or reciprocal

Table 1. Matrix of simple correlation coefficients for significant personality variables used in explaining financial position change

Variable	Risk aversion	Scientific orientation	Manifest anxiety	L Anxiety score	External-internal	Authoritarianism	Vocational interest-buyer	Vocational interest-banker	Gross significant vocational interest	Adaptability	Knowledge of scientific facts	Aggressive conservatism	Unresolved rebellion	Change in net worth
Risk aversion (*m*)[a]	1.000	−.111	−.246**	.030	.243**	.112	−.069	−.082	.070	−.109	.247**	−.130	−.155	.016
Scientific orientation (*w*)[b]		1.000	.212	.027	−.080	−.130	−.054	−.049	−.294**	−.013	.044	.205***	−.060	.283**
Manifest anxiety (*m*)			1.000	−.133	−.069	−.155	.178	.111	.259**	.243**	−.058	.049	.188	.115
L anxiety score (*w*)				1.000	−.315**	.131	−.008	.164	−.056	.258**	.256**	.014	.100	.177
External-internal (*w*)					1.000	.033	.233***	−.051	−.213***	−.029	.079	.181	−.047	.232***
Authoritarianism (*m*)						1.000	−.006	.227***	.255**	.174	.050	−.244**	.198***	.378*
Vocational interest-buyer (*w*)							1.000	.101	−.082	−.167	−.089	−.120	−.019	−.148
Vocational interest-banker (*m*)								1.000	.277**	.181	.075	−.188	.300**	.125
Gross signifiant vocational interest (*m*)									1.000	.128	.026	−.394*	.056	.460*
Adaptability (*m*)										1.000	.039	−.157	.104	.112
Knowledge of scientific facts (*w*)											1.000	−.171	−.059	−.158
Aggressive conservatism (*m*)												1.000	.015	.551*
Unresolved rebellion (*w*)													1.000	.195***
Change in net worth														1.000

* 1 percent level of significance.
** 5 percent level of significance.
*** 10 percent level of significance.
[b] (*m*) = men's variable.
[a] (*w*) = women's variable.

Table 2. "b" values and mathematical form of each independent variable

Estimated equation[a]

$$
\begin{aligned}
Y = & -35.59384 + \underset{(10.8)^{*}}{12.34937 X_{1\,\log_e}} + \underset{(7.1)^{*}}{5.40256 X_{2\,\log_e}} + \underset{(4.8)^{*}}{1.27003 X_{3\,\log_e}} \\
& + \underset{(6.0)^{*}}{2.33445 X_4^{-1}} + \underset{(4.4)^{**}}{34.85878 X_5^{-1}} - \underset{(4.8)^{*}}{52.30617 X_6^{-1}} - \underset{(2.8)^{**}}{.03487 X_7} + \underset{(10.3)^{*}}{0.7278 X_8} \\
& - \underset{(13.3)^{*}}{72.22000 X_9^{-1}} + \underset{(2.0)^{***}}{3.26893 X_{10}^{-1}} - \underset{(8.9)^{*}}{.29500 X_{11}} + \underset{(11.2)^{*}}{.23901 X_{12}} + \underset{(18.3)^{*}}{.68578 X_{13\,\log_e}}
\end{aligned}
$$

where:

Y = Change in net worth	X_7 = Vocational interest-buyer (w)
a = Y intercept	X_8 = Vocational interest-banker (m)
X_1 = Risk aversion (m)[b]	X_9 = Gross significant vocational interest (m)
X_2 = Scientific orientation (w)[c]	X_{10} = Adaptability (m)
X_3 = Manifest anxiety (m)	X_{11} = Knowledge of scientific facts (w)
X_4 = L anxiety score (w)	X_{12} = Aggressive conservatism (m)
X_5 = External-internal (w)	X_{13} = Unresolved rebellion (w)
X_6 = Authoritarianism (m)	

[a] Figures in parentheses are calculated F values. Statistically significant levels are indicated by: *** (10 per cent), ** (5 percent), and * (1 percent).
[b] (m) = men's variable.
[c] (w) = women's variable.

form. Psychological insight did not seem to suggest that any one mathematical form is superior. The dependent variable was considered in only linear form.

All of the positive signs for the variables were as expected, except for "unresolved rebellion." Possibly a degree of rebellion in the wife-partner toward past experiences is a motivating factor to seek personal environmental improvement through the farm business. Negative signs on the "vocational interest-buyer" variable for women and "gross significant vocational interest" variable for men were expected. Interests similar to those would take the farm couple away from the farm home and farm business and thus might detract from farm financial success.

Equations estimated for men or for women would be useful as predictors of possible financial success. However, the equation based on couples has greater predictive power ($R^2 = 0.731$ versus 0.703 for women alone and 0.666 for men alone). The R^2 values are relatively high, compared with previous studies on farm managerial ability.

In industrial studies attempting to predict success in various selling, research, or middle-management executive jobs, an R^2 of 0.5 has been considered strong. Up to 15 independent variables have been used in industrial prediction equations. Compared with a sample of FHA and PCA borrowers, industrial management personnel represent a more thoroughly prescreened group and less variance would be expected.

Implications for Financial-Managerial Studies

Our results suggest that consideration must be given to both husbands and wives as inputs into the farm family management process and particularly in evaluating the prospect of financial success. Since human problems are often different from farm business problems, both should be recognized and both require attention in successful use of farm credit.

The study results suggest that testing instruments can be developed to provide guidance for present and prospective farm operators, entrepreneurs, and farm credit agencies. The instruments may be used in advisory roles, too, by farm lenders and counselors. Repeated testing of the variables with different farm operators should be undertaken before the instruments are used for decision-making purposes.

Some questions that were employed in measuring each of the intercorrelated variables could be omitted. The "L anxiety" variable and some questions employed in measuring the "external-internal" variable appeared to measure approximately the same phenomena as did questions included in the "aggressive conservatism" and "gross significant vocational interest" variables. "Unresolved rebellion" questions and "vocational interest-banker" questions show a significant interrelationship,

apparently because both variables at least indirectly deal with "authority figures."

Application of the Nielson model to South Dakota borrowers disregarded past repayment performance and other management variables that are currently used in lending, such as yield levels, feed conversion ratios, and management returns. These variables may be significantly correlated with personality characteristics. However, borrowers generally do not provide lenders with sufficient and accurate data to fully develop the farm operating variables. The use of personality variables that can be measured readily in a lender's office may be a more feasible way to evaluate borrowers than to require complete farm operating data. Still, a lender could use physical production and financial data when they are available.

In some cases neither personality nor management performance variables alone may provide the insight and accuracy needed by farm lenders. If so, physical production and financial variables may need to be formally developed to supplement personality variables. A higher coefficient of determination may be developed by including nonpersonality variables; the number and importance of personality variables found in the South Dakota study may decrease and in some cases may be replaced by physical production or financial variables.

From a practical view the number of personality questions that are represented in the South Dakota results can be completed in less than two hours. The "b" values developed in the prediction equation, especially if they stay about the same in tests with new farmers, would have a direct use in evaluating farm loan applicants. Applicant scores on all variables would be added to give an index of probable net worth increase. Further research testing and use by lenders should evolve relevant "safe" and "high risk" ranges of Y values.

Several different methods of administration and evaluation of personality tests could evolve. Lending officers could be trained to routinely administer them and evaluate the result. Impartial third parties, such as counseling services, could be consulted for additional evaluation; or they could administer the tests and provide analyses to the respondent and his prospective lender. Counseling services could provide remedial help if needed.

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An Empirical Application and Evaluation of Discrete Stochastic Programming in Farm Management

ALLAN N. RAE

Discrete stochastic programming has been suggested as a means of solving sequential decision problems under uncertainty, but as yet little or no empirical evidence of the capabilities of this technique in solving such problems has appeared. This paper presents in some detail an empirical application of discrete stochastic programming, including a discussion of data requirements, matrix construction, and solution interpretation. Based on this empirical evidence, the problem-solving potential of the technique is evaluated.

OVER the past decade considerable attention has been directed to the explicit recognition of the effects of uncertainty in the analysis of decision problems in farm management [1, 2, 3, 9, 11, 12, 16, 17, 19, 26]. Among those who have examined the matter, Cocks [4] has suggested that a discrete stochastic programming model is at least potentially capable of providing solutions to sequential decision problems in which any number of the input-output coefficients and/or resource supplies could be described by discrete probability distributions. More recently [22], this author has provided a development of the discrete stochastic programming model, concentrating mainly on the specification of utility functions as objective functions, incorporation of additional information into the programming model, and valuation of such information. The purpose of this paper is to describe an empirical application of discrete stochastic programming to indicate its potential role in the solution of stochastic decision problems.

Specification of the Sequential Stochastic Decision Problem

Definition of the probability model is the first step in the construction of a stochastic programming problem. Since it will provide the "backbone" of the programming model, this step is probably the most important. It involves isolation of decision dates and therefore the division of the planning period into a number of stages; definition of possible random events (states of nature) within each stage; specification by the decision-maker of his subjective probabilities that each state will occur; and a statement of the appropriate information structure.

Next the activities and restraints of the decision model need to be defined; unlike deterministic linear programming models, sets of activities and restraints must be specified for each state of nature. The final step involves specification of the decision-maker's utility function or goals and conversion of this function (if necessary) to one suited to the programming model.

The probability model

A fresh-vegetable holding was chosen for the empirical study. This type of enterprise makes intensive use of both land and labor, and the random effects of weather and market prices play an important part in the ultimate outcome of a cropping program.

The holding comprised 20 acres of cropland, an unheated glasshouse, and a permanent labor force of five persons. In addition, a limited quantity of casual labor was available during the year. Possible cropping activities included winter-, spring- and summer-harvested cauliflower, spring-harvested cabbage, spring and summer crops of lettuce, early- and main-crop tomatoes, beetroot, carrot, cucumber, and pumpkin. The glasshouse could accommodate crops of either tomato or cucumber. To satisfy rotational requirements, the grower required that no more than five acres of any crop be cultivated in any year.

The annual production season was divided into three stages: June to September (stage one); October to January (stage two); February to May (stage three). Thus the model permitted decisions to be formulated on only three occasions within the year—at the beginning of June, October, and February.

The appropriate information structure was that at the beginning of stage t, $t=1, 2, 3$, the manager would have full knowledge about the outcomes of the previous $t-1$ stages,[1] but only probabilistic knowledge (although condi-

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[1] The outcome of stage $t-1$ for $t=1$ would be the outcomes of previous seasons, known with certainty at the beginning of the current season.

tional on previously accumulated knowledge) of the outcomes of stages t, $t+1, \cdots$, etc.

The manager was satisfied with the assumption that all variability in his production and marketing data was a function of either weather or market prices. The states of nature for each stage of the decision problem were therefore specified as several levels of "weather conditions" and crop prices. All stochastic coefficients other than prices, such as planting and harvesting dates, yields, and labor and machinery inputs for the various production and harvesting operations, were all dependent upon the prevailing weather. For example, the number of spray applications necessary might have to be increased if weather is favorable to disease incidence, or land cultvation may take longer in unsuitable weather.

Although the weather variable was separately defined for each stage of the decision problem, the price variables required definition only for the stage during which the crops were harvested. Thus the random variables "spring cabbage price" and "spring lettuce price" were appropriate only to the second stage and the random variable "main-crop tomato price" only to the third stage of the decision process.[2]

The next task was to determine a suitable partitioning of the distribution of values that each random variable could take. The complete distributions of spring cabbage, spring lettuce, and main-crop tomato prices were approximated by partitioning each into two segments, giving two levels ("high" and "low") of each price. The complete distribution of outcomes of the weather variables of the first two stages were partitioned into two segments and that of the third-stage weather variable into three segments, because the crops cultivated over the first two stages were generally less sensitive to climatic variability than those cultivated during the third stage.

No strict meteorological specification was assigned to the various levels of the weather variables; these were simply named "good," "normal," or "bad." This approach has been adopted in many farm management studies[3] and is believed to be justified here since weather outcomes have been defined similarly to the way many farmers measure weather outcomes. For example, the *grower* knows what he means by "good" weather, can thus identify it when it occurs, and can specify crop budgets pertinent to good weather. Thus all possible combinations of weather variables (rainfall, temperature, etc.) that might be measured by a weather index have been replaced by a relatively small number of broadly defined weather states.[4]

Formalization of the sequential probability model

Using the notation introduced in [22], R is a model that provides a mathematical representation of the t-stage sequential probability model. R will consist of a number of submodels:

$$R_{n_t t}; \qquad t = 1, \cdots, T$$
$$n_t = 1, \cdots, N_t$$

where n_t is the number of possible random experiments that "nature" could perform in the tth stage. The sets of possible nature states appropriate to each submodel $R_{n_t t}$ will be given by

$$\text{(1)} \qquad \xi_{n_t t} = \{e_{j,n_t t}; j = 1, \cdots, s\}$$

with associated probabilities given by the sets:

$$\text{(2)} \qquad P_{n_t t} = \{p_{j,n_t t}; j = 1, \cdots, s\}.$$

Thus the mutually exclusive and collectively exhaustive set of all joint events of the sequential probability model will be given by the direct product of all $R_{n_t t}$ and may be represented by the set:

$$\text{(3)} \qquad \Theta = \{\theta_r; r = 1, \cdots, k\}.$$

Returning to the empirical problem, the sequential probability model was completed with the manager making a purely subjective assessment [23] of the probabilities of the events in all $\xi_{n_t t}$. The sequential probability model is presented as a tree diagram in Figure 1. Here,

[2] The grower believed prices of these three crops to be the most variable, and in practice his subjective probabilities of unsatisfactory prices being received influenced his planting decisions for these crops.

[3] For example, Halter and Dean [11, ch. 7] specify six "range condition indices" to represent "poor" to "very good" climatic conditions.

[4] Specification of a weather index and the production data relevant to each index number is not impossible [7, 8, 24] but might provide difficulties in *individual* farm applications of stochastic programming; the farmer may not be familiar with the indices, and hence aggregated or experimental data may have to be substituted in place of his subjective judgments. However, in research applications of stochastic programming, or in "benchmark" regional models, the adoption of a weather index to specify weather states would be the more sophisticated approach.

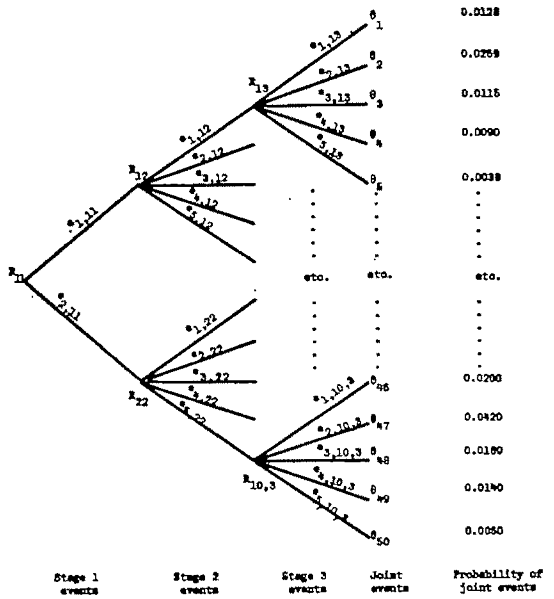

Figure 1. The probability model

$$t = 1, 2, 3, \quad \text{and}$$

$$n_t = \begin{cases} 1 & \text{for } t = 1 \\ 1, 2 & \text{for } t = 2 \\ 1, 2, \cdots, 10 & \text{for } t = 3. \end{cases}$$

The sets $\xi_{n_t t}$ comprise all possible events (that is, those with nonzero probabilities) of each probability model $R_{n_t t}$. Table 1 explains the notation in the probability model and gives the subjective probability of each state of nature. The joint probabilities of some of the 50 joint events θ_r are given in Figure 1; for example, the joint event, θ_1, comprises events $e_{1,11}$ followed by $e_{1,12}$ in the second stage and $e_{1,13}$ in the third stage, with a probability, $p(\theta_1)$, given by:

$$\begin{aligned} p(\theta_1) &= p_{1,11} \times p_{1,12} \times p_{1,13} \\ &= 0.50 \times (0.80 \times 0.16) \times 0.20 \qquad (4) \\ &= 0.0128. \end{aligned}$$

Some further comments may be made on the probability model. First, the decision-maker assumed the likelihood that weather states in any one stage would be independent of the likelihood of weather states in any other stage. Second, weather and prices were assumed to be dependent in any one stage only to the extent that bad weather in the second stage would damage lettuce and cabbage crops so as to make them unmarketable and would damage cauliflower and beetroot crops to the extent that they could be marketed only as low-grade produce, while bad weather in the third stage would produce a low-quality tomato crop that could be sold only to processing factories.[5] In both cases low-quality produce could be disposed of only at a price below that for average-quality produce. Third, the grower assumed independence between tomato prices received in the third stage and the cabbage and lettuce prices of the second stage but was not prepared to assume independence between cabbage and spring lettuce prices since he expected such prices to be positively correlated. In this case the marginal, conditional, and thus joint probabilities—again subjective—were calculated.

Compilation of input-output data

The collection of input-output data for stochastic linear programming models is a con-

[5] Although prices could be expected to be dependent upon weather in the macro sense, the assumption of independence would appear acceptable for individual producers.

Table 1. Nature states and subjective probabilities

Event	Description	Probabilities
Stage 1		
$e_{1,11}$	good weather	0.50
$e_{2,11}$	bad weather	0.50
Stage 2		
$e_{1,12}, e_{1,22}$	good weather, low lettuce and high cabbage price	0.80×0.16
$e_{2,12}, e_{2,22}$	good weather, low lettuce and low cabbage price	0.80×0.14
$e_{3,12}, e_{3,22}$	good weather, high lettuce and high cabbage price	0.80×0.64
$e_{4,12}, e_{4,22}$	good weather, high lettuce and low cabbage price	0.80×0.06
$e_{5,12}, e_{5,22}$	bad weather	0.20
Stage 3		
$e_{1,13}, \cdots, e_{1,10,3}$	bad weather	0.20
$e_{2,13}, \cdots, e_{2,10,3}$	normal weather, high tomato price	0.60×0.70
$e_{3,13}, \cdots, e_{3,10,3}$	normal weather, low tomato price	0.60×0.30
$e_{4,13}, \cdots, e_{4,10,3}$	good weather, high tomato price	0.20×0.70
$e_{5,13}, \cdots, e_{5,10,3}$	good weather, low tomato price	0.20×0.30

siderable task, since budgets of activity operations, resource requirements, and cash flows must be constructed for each possible state of nature. For example, cauliflower crops were cultivated during the first and second stages of the production year. Since there were four possible outcomes of weather over this period (good weather in stage one followed by bad in stage two, good followed by good, bad followed by good, and bad followed by bad), four separate budgets were required for each cauliflower crop.

Once the above data had been collected for all activities, the per unit requirement of each activity could be specified for each resource under any of the 50 joint outcomes of the sequential probability model. Activities to be included in the programming model were outlined earlier; restraints included monthly land and labor supplies, rotational restraints, glasshouse area, and limits on the amount of casual labor that may be hired each month. The model did not include restraints on the supply of cash available since the grower believed he had access to sufficient funds to finance the season's production, no matter what the outcome of nature. All yield coefficients (except those of the glasshouse crops),[6] the majority of labor input-output coefficients, costs, and prices, and several of the land input-output coefficients were treated as stochastic. All resource supplies, however, were assumed known with certainty at the beginning of the planning period.[7]

The utility model

The following goals of the decision-maker, in order of importance, were specified: (1) to attempt to achieve a net income of at least $6,000 per annum; (2) to minimize income variability from one year to the next; and (3) to strive to produce good quality produce. The third goal is the only one that cannot readily be measured in terms of money income. The grower's desire to produce good quality produce, though, had already been reflected in the specified activity budgets; thus his striving to achieve this goal was the same as his efforts to achieve the results implied by his budgets. Given that the grower's decision-making will in part be oriented towards this end, only the first two goals were explicitly included in the objective function of the decision model.

As both of these goals may be measured in terms of annual net income, the decision-maker's utility function, in relation to annual net income, was estimated [16, pp. 54–69]. Discounting of net incomes for utility function estimation [22] was considered unnecessary since only one year separated the initial decision date and the planning horizon. The utility function was derived over a range of annual net incomes from −$16,000 to $30,000, which was assumed to include all likely net incomes.

The 17 (U, $) pairs obtained from the questioning procedure are plotted in Figure 2. The manager's utility function for money income was obviously nonconvex, exhibiting risk aversion over the range of positive net incomes but risk preference for the avoidance of negative net incomes. An interesting observation can be made on the shape of the utility function. One of the decision-maker's goals was to achieve at least $6,000 per annum, if possible. This goal is confirmed by the utility function, where marginal utility is almost constant over the income range of −$7,000 to $6,000 but drops rapidly for incomes over and above $6,000.

Construction of the Discrete Stochastic Programming Matrix

The information structure defined earlier implied that decisions formulated at the beginning of any stage could be a function only of the observed outcome of all previous stages. Therefore the design of the stochastic programming matrix would be similar to that given by model (6) in [22]. A diagrammatic representation of the matrix is given in Table 2, where the various submatrices and vectors are defined as follows:

$A_{g,11}$	is matrix of input-output coefficients relevant to stage one given good weather;
$A_{b,11}$	is a matrix of input-output coefficients relevant to stage one given bad weather;
x_{11}	is a vector of activity levels to be initiated at the beginning of the planning period;
$A_{g,12}$ and $A_{b,12}$	are matrices of input-output

[6] Production coefficients of glasshouse activities were not treated as random, as these crops were cultivated in a partly controlled environment and a greater degree of certainty would surround the production of these crops than outdoor crops.

[7] Although this was true for the land and glasshouse resources, the supply of labor available during future months would in fact be a random variable. The quantity of labor required by crops, though, was considered more variable than the quantity of labor that would actually be available, so labor input-output coefficients were treated as random and labor supplies as deterministic coefficients.

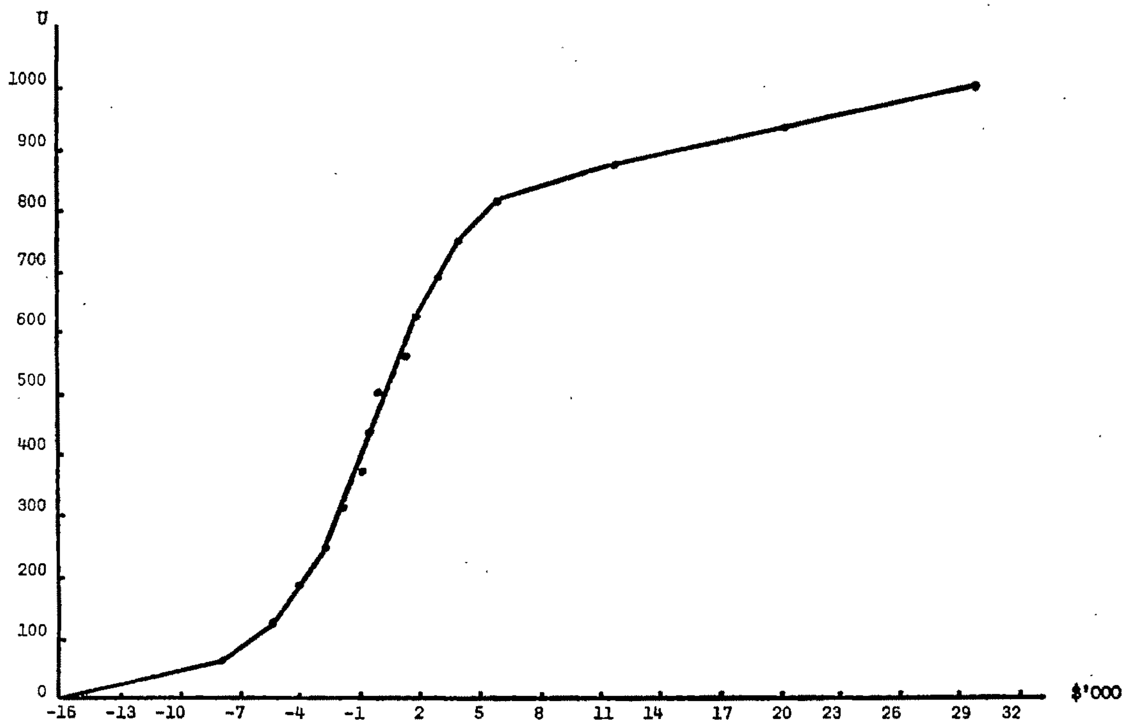

Figure 2. Linear separation of the utility function

coefficients relevant to stage two, given good weather in stage one, and good and bad weather, respectively, in stage two;

$A_{g,21}$ and $A_{b,22}$ may be defined as above, except that they are relevant to good and bad weather, respectively, in stage two following bad weather in stage one;

x_{12} and x_{22} are vectors of second-stage activity levels to be initiated following the observation of good or bad weather, respectively, in stage one;

$\left.\begin{matrix} A_{b,13} \cdots A_{b,10,3} \\ A_{n,13} \cdots A_{n,10,3} \\ A_{g,13} \cdots A_{g,10,3} \end{matrix}\right\}$ are matrices of input-output coefficients relevant to stage three, given bad, normal, or good weather, respectively, and for each of the ten possible outcomes of stage two;

$x_{13} \cdots x_{10,3}$ are vectors of third stage activity levels corresponding to each possible stage two outcome;

$c_{ntt}^{(r)}$ are vectors that contain activity payoffs and costs relevant to the rth joint event θ_r, $r=1, \cdots, 50$;

b is a vector of resource supplies;

$w^{(r)}$ is a vector of intermediate activities that transforms the net payoff value given the rth joint event to a utility value, $u^{(r)}$, $r=1, \cdots, 50$, by means of the vector of coefficients d;

x_{11}^* is a vector that includes only those activities[8] that are continued into the second stage;

x_{12}^* and x_{22}^* are vectors that include only

[8] These could be production activities *or* activities that transfer resources from one period to the next. In the empirical matrix, however, only activity acreages were transferred from one stage to the next. In stochastic programming models of farm development, or capital budgeting models in general, supplies of *resources* (such as land and cash) would require to be transferred from one stage to the next. Although this could be accomplished in the same manner as the present model transfers activity acreages, it would be more efficient (in terms of the number of rows in the matrix) to transfer resource supplies directly to the appropriate row, rather than to create new rows as in the above matrix.

Table 2. Diagrammatic representation of the stochastic programming matrix

$A_{g,11}x_{11}$								$\leq b_{g,11}$
$A_{b,11}x_{11}$								$\leq b_{b,11}$
	$A_{g,12}x_{12}$							$\leq b_{g,12}$
	$A_{b,12}x_{12}$							$\leq b_{b,12}$
		$A_{g,22}x_{22}$						$\leq b_{g,22}$
		$A_{b,22}x_{22}$						$\leq b_{b,22}$
			$A_{b,13}x_{13}$					$\leq b_{b,13}$
			$A_{n,13}x_{13}$					$\leq b_{n,13}$
			$A_{g,13}x_{13}$					$\leq b_{g,13}$
			$\ddots$					$\vdots$
				$A_{b,53}x_{53}$				$\leq b_{b,53}$
				$A_{n,53}x_{53}$				$\leq b_{n,53}$
				$A_{g,53}x_{53}$				$\leq b_{g,53}$
					$A_{b,63}x_{63}$			$\leq b_{b,63}$
					$A_{n,63}x_{63}$			$\leq b_{n,63}$
					$A_{g,63}x_{63}$			$\leq b_{g,63}$
					$\ddots$			$\vdots$
						$A_{b,10,3}x_{10,3}$		$\leq b_{b,10,3}$
						$A_{n,10,3}x_{10,3}$		$\leq b_{n,10,3}$
						$A_{g,10,3}x_{10,3}$		$\leq b_{g,10,3}$
$-Ix_{11}^{*}$	Ix_{12}^{*}							≤ 0
$-Ix_{11}^{*}$		Ix_{22}^{*}						≤ 0
	$-Ix_{12}^{**}$		Ix_{13}^{**}					≤ 0
	$\vdots$		$\ddots$					$\vdots$
	$-Ix_{12}^{**}$			Ix_{53}^{**}				≤ 0
		$-Ix_{22}^{**}$			Ix_{63}^{**}			≤ 0
		$\vdots$			$\ddots$			$\vdots$
		$-Ix_{22}^{**}$				$Ix_{10,3}^{**}$		≤ 0
$-c_{11}^{(r)}x_{11}$	$-c_{12}^{(r)}x_{12}$	$-c_{22}^{(r)}x_{22}$	$-c_{13}^{(r)}x_{13}$ $\cdots$	$-c_{53}^{(r)}x_{53}$	$-c_{63}^{(r)}x_{63}$ $\cdots$	$-c_{10,3}^{(r)}x_{10,3}$	$+\gamma' w^{(r)}$	$\leq K^{(r)}$
							$-\delta' w^{(r)} + u^{(r)}$	≤ 0

those second-stage activities that may be initiated in the first stage;

x_{12}^{**} and x_{22}^{**} are vectors that include only those second-stage activities that may be continued into the third stage;

$x_{13}^{**} \cdots x_{10,3}^{**}$ are vectors that include only those third-stage activities that may be operated in the second stage.

It should be noted that, for example, the second-stage events $e_{1,12}$ to $e_{4,12}$ refer to good weather *and* a given combination of spring lettuce and cabbage prices (see Table 1). Since the model did not include cash restraints, all stochastic cash coefficients could be entered directly into the relevant vectors $c_{nit}^{(r)}$ of Table 2. Thus the matrix $A_{g,12}$ contains coefficients given good weather in stage two following good weather in stage one, but no cash coefficients.[9]

That the vectors of activity levels x_{nt} form a strategy is readily apparent from Figure 3. The vector of activity levels x_{11} would be initiated at the beginning of stage one; either x_{12} or x_{22} would be initiated at the beginning of stage two, depending on whether event $e_{1,11}$ or $e_{2,11}$ was observed in the previous stage; and any one of the vectors x_{13} to $x_{10,3}$ could be initiated at the beginning of the third stage, depending on the observed outcome of the second stage.

To illustrate some more detailed aspects of

[9] Had the model included cash restraints, matrix $A_{g,12}$ would have had to be replaced by *four* matrices, $A_{1,12}$ to $A_{4,12}$ (which *would* include cash restraints).

matrix construction, the stage one coefficients, that is, matrices $A_{g,11}$ and $A_{b,11}$ and vectors $b_{g,11}$, $b_{b,11}$, and $c_{11}^{(r)}$ are presented in Appendix Table A. First, each submatrix of the model, such as (5):

$$(5)\qquad \begin{bmatrix} A_{g,11}x_{11} \leq b_{g,11} \\ A_{b,11}x_{11} \leq b_{b,11} \end{bmatrix}$$

is a "fat" matrix [15] in that the activity levels in the solution to the problem, in this case the vector of stage one activity levels x_{11}, must be permanently feasible.[10] Thus the stage one cropping program, which is formulated at the beginning of June, must remain feasible until the second decision date, given the occurrence of either good or bad weather during the intervening period.

Second, each submatrix may be constructed as a "two-stage" programming model [5]. Although it was necessary to decide upon the cropping program for any stage at the beginning of that stage, it may not be necessary to make other decisions, such as the quantity of casual labor to be hired, until the time when the decision is actually required. Thus, given the initial cropping program x_{11} from Appendix Table A, additional labor may be hired (at a "penalty cost" of 80 cents per hour) during stage one to compensate for any infeasibilities that may appear as the weather outcome is revealed.

Third, all rows within each submatrix should be tested for dominance [13, pp. 151–164]. Because of the manner in which submatrices are constructed it is possible that many rows will be dominated; that is, the coefficients given one state of nature may dominate those given another state. The removal of such rows,[11] then, will help to reduce the dimensionality problem encountered in sequential decision problems.

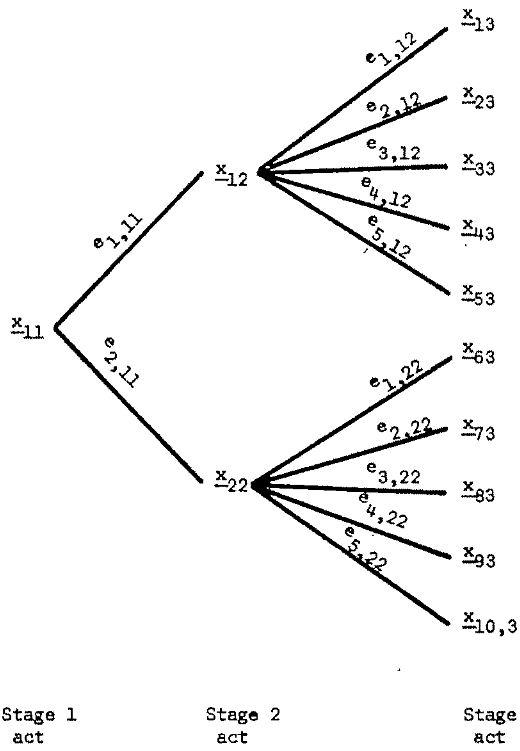

Figure 3. The structure of the solution strategy

Incorporation of the utility function into the matrix

For purposes of the stochastic linear programming model, the utility function was closely approximated by a number of linear segments,[12] as shown in Figure 2. For example the first \$8,000 of net income above −\$16,000 (that is, from −\$16,000 to −\$8,000) provided a utility of 62.5 units. Thus each dollar of the first \$8,000 of net income was assumed to provide a constant marginal utility, equal to 62.5/8000 units per dollar. The manner in which the (linearly-segmented) utility function was built into the programming matrix is illustrated in

[10] Since each submatrix was constructed as a "fat" matrix, the model tended to be a rather "conservative" representation of the decision problem. This was because the number of decision dates had been restricted to three and decisions could be formulated only on these occasions. In practice coefficient values would be revealed, and hence decisions made, gradually over time and Cocks' "constrained passive" or "constrained active" formulations [4] would make fuller use of information received by the decision-maker. These latter formulations, however, would have required the definition of a larger number of decision dates and therefore a much larger programming problem. Thus the above empirical "less-constrained fat" formulation fails to make full use of all information *as it becomes available* during any stage but approximates the situation by making use of all collected information at the chosen decision dates (and hence is obviously superior to the single-stage fat formulation in that decisions *are* dependent on information learned over the planning period).

[11] Dominated rows removed from the submatrix of Appendix Table A included the June, July, and August land restraints given good weather, and all land restraints, all rotation restraints, and the glasshouse restraint given bad weather.

[12] As the utility function was nonconvex, and thus violated the convexity requirement of linear programming, a linear separable programming algorithm was required to obtain a solution to the problem; see [10, ch. 4].

Table 3. The stochastic separable programming objective function[a]

	B	Income generating activities ($x_{n_t t}$)	Special separable programming activities w_1^1	$w_2^1 \cdots w_7^1$	$w_8^1 \cdots w_1^{50}$	$w_2^{50} \cdots w_7^{50}$	w_8^{50}	Utility (θ_1) $\cdots$ Utility (θ_{50})
Objective coefficients (probabilities)		0	0	$0 \cdots 0$	$0 \cdots 0$	$0 \cdots 0$	0	$0.0128 \cdots 0.0060$
Upper bound			1.0	$1.0 \cdots 1.0$	$1.0 \cdots 1.0$	$1.0 \cdots 1.0$	1.0	
Net income pool (θ_1)	$965 \geq$	$c_{n_t t}^{1}$	8000	$2500 \cdots 6150$	18050			
$\vdots$	$\vdots$	$\vdots$			$\ddots$			
Net income pool (θ_{50})	$965 \geq$	$c_{n_t t}^{50}$			8000	$2500 \cdots 6150$	18050	
Utility pool (θ_1)	$0 \geq$		-62.5	$-62.5 \cdots -62.5$	-125.0			1.0
$\vdots$	$\vdots$				$\ddots$			$\ddots$
Utility pool (θ_{50})	$0 \geq$				-62.5	$-62.5 \cdots -62.5$	-125.0	1.0

[a] The separable programming algorithm employed required that $0 \leq w_i^r \leq 1$, $i = 1, \cdots 8$, $r = 1, \cdots 50$, and the basis entry restrictions on the special variables allowed only one variable of a set (each set is indexed by r, $r = 1, \cdots, 50$) of special variables to be at an intermediate level at any one time. All variables that precede it must be at their upper bounds.

Table 3. Here the vectors $c_{n_t t}^{(r)}, r=1, \cdots, 50$, have as coefficients the costs (positive) and returns (negative) per unit of the activities $x_{n_t t}$, given the occurrence of each joint outcome $\theta_r, r=1, \cdots, 50$. Each set of separable activities $w_i^r, i=1, \cdots, 8$, then simply transforms net income into its utility value, for each joint outcome. Thus formulation of the objective function was similar to that of [22, model (8)], except that cash flows were not discounted to their present values.

The coefficient of \$965 in the B column for the "net income pool" restraints was derived as follows: Assume, for example, that a strategy provided, given the occurrence of θ_1, a net income (returns less variable costs) of \$15,035. On subtraction of fixed costs (which were \$15,035), profit would be reduced to zero. From the utility function of Figure 2 it is seen that the utility value of a zero annual net income is obtained by moving \$16,000 units to the right of the origin, so the separable variables of the first set would need to enter the solution to a total level of 16,000 units. This would be achieved, since the total value of dollars in the net income pool would equal \$965+\$15,035, or \$16,000.

Now the Bayesian criterion of maximizing expected utility may be written:

$$\text{maximize } E(u) = p'u = p(\theta_1)u(\theta_1) + \cdots + p(\theta_{50})u(\theta_{50}) = 0.0128[\text{utility } (\theta_1)] + \cdots + 0.0060[\text{utility } (\theta_{50})]. \tag{6}$$

Solutions to the Stochastic Programming Problem

Estimating the scope for improvement over existing plans

Before solving a stochastic programming problem it would be sensible to make an estimate of the maximum increase in expected utility that could be achieved by the stochastic model in comparison with the outcome of a deterministic formulation of the problem. This estimate could then be used as additional information in deciding whether or not to proceed in the solution of the stochastic programming problem.[13]

To reduce the stochastic problem to a deterministic problem all random coefficients were replaced with their expected values. The optimal solution to this problem will be a member of the set of feasible solutions to the stochastic programming problem only if it remained feasible given the occurrence of any of the 50 possible joint events. It was easily shown by budgeting that the solution to the deterministic problem, if adopted by the grower, would be infeasible under some eventuating nature states.

To obtain the true (or feasible) distribution of outcomes the resource requirements of the deterministic solution, for all possible nature outcomes as described by the coefficients of the stochastic programming matrix, were deter-

[13] No definite conclusion as to whether the stochastic model would be economically worthwhile may be reached, since its outcome would not of course be known ex ante. The only definite conclusion would arise in the case where the cost of the model exceeded the scope for improvement, in which case the study should be terminated.

mined by simple budgeting. All infeasibilities were then located, and the grower outlined the modifications to this solution that he would make to overcome the infeasibilities. In this way a feasible strategy was obtained, giving an expected income of $9,638 and an expected utility of 706 units. These values will be used as benchmarks with which to compare outcomes of the stochastic solutions.

Next, the decision problem was formulated as a passive stochastic programming problem [25]:

$$\begin{aligned} &\text{maximize} \quad Z^{(r)} = c^{(r)}x \\ (7)\quad &\text{subject to} \quad A^{(r)}x \leq b^{(r)}; \; r = 1, \cdots, 50 \\ &\qquad x \geq 0 \end{aligned}$$

Thus the passive formulation, which assumes *perfect* knowledge of the future, required the solution of 50 independent subproblems. The matrix for each subproblem differed from that used by the deterministic programming model in that all random coefficients were replaced by a value drawn from the appropriate discrete distributions depending on the choice of θ_r, the eventuating nature state.[14] On solution of the passive model a discrete distribution of money outcomes was obtained, which can be converted to the appropriate utility distribution.[15] To summarize the outcome of the passive model: Provided that the grower possessed perfect information on the future outcome of nature, he could achieve on average a utility of 804 units and a net income of $14,214.

At this stage the scope for improvement over the deterministic linear program may be computed. If the grower adopted the solution provided by the deterministic model, expected *net income* could be increased by up to $4,576 (or 48 percent) through the explicit recognition of risk in the decision model. Since his utility was a nonlinear function of money, however, the method described earlier by the author [22] was used to determine the maximum amount of money the decision-maker could afford to pay for perfect information and remain as well off, in terms of *expected utility*, as before. This was found to be $4,236, and it would appear that the potential of stochastic programming in providing better decision rules, in this case, was considerable.[16]

Some aspects of the optimal solution

Next, the *real* problem was solved with the stochastic programming model formulated earlier in the paper.[17] The 50 activities labelled "utility (θ_1)" to "utility (θ_{50})" of Table 3 were included in the optimal solution, and their levels indicated the distribution of possible utility outcomes. The expectation of this distribution, that is, the maximum value of expected utility, was 746 units. To obtain the distribution of dollar outcomes each utility value was converted to its equivalent value of net income, and the expectation of the resulting distribution was $11,134.

The decision rules that together made up the optimal strategy are presented in Appendix Table B and may be identified as consisting of the activity vectors $x_{n_t t}$ of Figure 3. At the beginning of the production period the grower should initiate activities in accordance with the (single-valued) stage one decision rule, which comprised the activity vector x_{11}. That is, he should allocate 5.00 acres of land to the winter cauliflower activity, 2.48 acres of land to the spring cabbage activity, and so on. At the beginning of the second and third stages the appropriate activity vector may be chosen, depending on the observed outcome of the previous stage(s).

From the solution it is possible to compute *probability distributions* of resource use and hence the probability of any resource being fully utilized. For example, instead of compiling a budget that included statements such as "exactly 109 hours of labor will be required in six months' time," the distributions of possible labor employment for future months can be prepared and presented to the decision-maker. From these results he might be better able, for example, to allocate jobs of an overhead nature to those months when sufficient labor is *most likely* to be available.

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[14] Note that the size of each submodel of the passive formulation will be no greater than that of the deterministic linear program.

[15] Since passive stochastic programming assumes perfect knowledge of future outcomes, subproblems are not characterized by probability distributions of outcomes. Hence maximization of net money income (the objective of (7)) will be equivalent to the maximization of utility, as the decision-maker's utility function increased monotonically.

[16] That is, if $4,236 were added to fixed costs of each subproblem of the passive model, the resulting optimal utility distribution would have an expectation of 706 units, which is identical with that of the deterministic strategy.

[17] The stochastic programming matrix consisted of 838 restraints (of which 490 could be expressed as upper bounds) and 730 columns, and the problem was solved without difficulty in a single run of 80 minutes using a 360/50 system and the MPS/360 separable programming algorithm. (Matrix density was 1.2 percent.)

Shadow prices

The solution to the stochastic programming problem will provide a complete (discrete) distribution of resource shadow prices, one for each possible state of nature. These marginal values can be obtained from the final simplex tableau and will be the coefficients in the appropriate (nonbasic) "slack" columns and the rows of the basis that represent the utility levels. Thus distributions of marginal utilities can be derived,[18] and the expected marginal utility will be given by

$$E(mu) = \sum_{r=1}^{k} p(\theta_r) mu_r \tag{8}$$

From these distributions it might be observed that although the expected marginal utility imputed to a resource must be nonnegative, the *actual* outcome drawn from the distribution of marginal values may be negative.

As the decision-maker's utility was a nonlinear function of net income, the maximum prices he should bid for additional resources can be determined as described in [22]. For example, although purchase of the marginal land unit would increase expected net income by $173 the true value to the grower of the land was $194 per acre. In other words, after paying $194 for the resource increment and optimally adjusting resource allocation, the resulting value of expected utility would be exactly the same as that of the original optimal strategy.

In linear programming under certainty full-capacity utilization of resources is a necessary condition for those resources to be imputed a positive price. It follows from the Kuhn-Tucker conditions, though, that in stochastic linear programming a resource may only be used to full capacity given just one state of nature to be imputed a positive (or zero in the degenerate case) price [21, ch. 5]. In this case the resource would *not*, on average, be used to full capacity but might still be imputed a positive expected valuation. In other words, the resource may exhibit *both* expected excess capacity and an expected positive valuation.[19]

The expected cost of uncertainty

The expected cost of uncertainty is the "price" the decision-maker must pay for having to make decisions in the face of uncertainty and will be equal to the expected value of perfect information. This value may be determined (as described in [22]) by calculating that sum of money which the decision-maker could afford to pay for perfect information and remain as well off, in terms of expected utility, as he would have been with the optimal strategy appropriate to the actual information structure. It was found that this value was $2,562, and it would appear that efforts to obtain further information on the values that random variables might take on could be worthwhile.[20] Note that this value is not identical with the increment in expected income of $3,080 (that is, $14,214 −$11,134) that would result from the acquisition of perfect information, since the grower's utility function was not linear with money.

The value of the optimal strategy

Using the feasible distribution of outcomes of the deterministic solution as a benchmark, it was possible to compute the value of the optimal strategy to the stochastic problem over that of the deterministic formulation. This will simply be the amount of money which, if added to fixed costs in the stochastic model, would reduce expected utility to that of the deterministic solution. Hence, if the grower was operating the strategy obtained from the deterministic model, he could afford to pay up to $1,570 to obtain the optimal solution to the stochastic problem. If he paid exactly this amount, he could expect a utility level identical with that provided by the deterministic strategy.[21]

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[18] Should the utility function be multidimensional [22], it will be possible to obtain from the final simplex tableau distributions of shadow prices measured in terms of each factor. If utility is additive, the expected marginal utility imputed to a resource will comprise a weighted sum of expected marginal utilities measured in terms of each factor, where the weights are the "trade-off" coefficients of the original utility function. Should utility be multidimensional but lexicographic, however, resource expected marginal utilities will not be single-valued since the trade-off coefficients will *not* be measurable. Then, resource marginal productivity would be indicated by a *vector* of expected marginal utilities, and the expected marginal utilities of various resources would have to be compared using a lexicographic ordering system [21, ch. 5].

[19] Naslund [18, chs. 3 and 4] has obtained a similar result with chance-constrained programming models.

[20] That is, if $2,562 were added to fixed costs of each submodel of the passive formulation, the resulting utility distribution would have an expectation identical with the expected utility from the optimal strategy.

[21] The stochastic programming problem was solved under the assumption that solution costs were zero. In practice, the cost of problem-solving (e.g., the analyst's fee) would likely be known before the problem was solved and should be added to fixed costs when utility is not linear with income (since the conventional assumption that fixed costs do not affect decisions will no longer be true).

Evaluation of Discrete Stochastic Programming in Farm Management

This paper has described in some detail an empirical application of discrete stochastic programming to a sequential stochastic decision problem in farm management. As with many "first" applications of new methodology, the empirical model could be criticized on a number of points, all of which bear on the problem of obtaining an "adequate" representation of reality in mathematical models. For example, some critics might argue that the empirical model included too few states of nature to be really useful in practice. Some such critics, however, may quite happily formulate and make recommendations from *deterministic* linear programming models with little or no thought as to the *actual* outcomes of their recommendations, simply because deterministic, but not stochastic, linear programming is a commonly used technique.

Be that as it may, however, there is no doubt that the empirical model would have been much improved had a greater number of nature states been specified and had decisions been allowed to be formulated at more frequent intervals, thus making more efficient use of information received as the planning period unrolls. Generally, however, an increase in the number of random variables, the number of possible values of each random variable, or the number of decision dates within the planning period will result in a more than proportionate increase in the size of the programming matrix. Thus a dimensionality problem exists and, with limited research funds, it is important that the model be economically justified; that is, we should seek *economic* rather than *absolute* optimal solutions.

It can be expected, however, that present and future research into optimization theory and large-scale systems will gradually reduce the problem of dimensionality. For example, the linear programming decomposition principle [14, 20] has already allowed the solution of problems with up to 3×10^4 restraints and 10^6 variables [6, pp. 10 and 14]. It should be observed from Table 2 that the stochastic programming matrix is of a structure ideal for solution using a decomposition algorithm, and a "stochastic programming package" comprising a matrix generator, decomposition algorithm, and report writer would be most useful. Given adequate computing facilities and funds, there is no doubt that stochastic models of much greater sophistication than that described above could be solved. It would also be expected, though, that if such large stochastic programming models were to be economically justified, they would probably be designed as research or regional models rather than to give advice only to individual farmers. However, less complex stochastic models might be justified for the formulation of advice for individuals;[21] at least the models could be designed so as to recognize the most important aspects of risk on the outcome of farm plans, something that deterministic linear programming fails to do.

[21] With the empirical problem described above, for example, the stochastic model was demonstrated to be $1,570 "better" than the deterministic model and would have been justified if the difference in analyst's fees for both models were less than $1,570.

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Appendix

Table A. Portion of the stage one submatrix

	B	Winter cauliflower	Spring cauliflower	Summer cauliflower	Spring cabbage	Early tomato	Spring lettuce	Summer lettuce	Beetroot	Carrot	Glasshouse tomato	Glasshouse cucumber	Hire labor June—good	Hire labor July—good	Hire labor Aug.—good	Hire labor Sept.—good	Hire labor June—bad	Hire labor July—bad	Hire labor Aug.—bad	Hire labor Sept.—bad
Upper bound[a]					5	5			5	5			650	650	650	650	650	650	650	650
Good weather:																				
Land—September	20≥	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0										
Labor—June	828≥	58.9					192.6		3.0				−1							
Labor—July	638≥	33.0	58.9		23.0		35.5		7.5			5.0		−1						
Labor—August	472≥	34.0	33.0		47.5	100.0	35.5		2.0		6.0	6.0			−1					
Labor—September	814≥	198.0	34.0	39.0	48.0	3.5	35.5	2.8	4.5	3.0	11.5	11.5				−1				
Cauliflower rotation	5≥	1.0	1.0	1.0																
Lettuce rotation	5≥						1.0	1.0												
Glasshouse	1≥										1.0	1.0								
Bad weather:																				
Labor—June	828≥	20.0					20.0		6.0								−1			
Labor—July	638≥	47.8	20.0		26.0		182.6		15.0			5.0						−1		
Labor—August	472≥		47.8		63.0	100.0	3.0		4.0		6.0	6.0							−1	
Labor—September	814≥	5.0				7.0	3.0		3.0	6.0	11.5	11.5								−1
Net income ($r=1$–25)	965≥	−817.4	77.2	75.6	32.5	86.9	128.3	14.4	64.0	1.2	33.8	90.9	0.8	0.8	0.8	0.8				
Net income ($r=26$–50)	965≥	76.6	76.6		32.5	86.9	137.2		67.2	2.0	33.8	90.9					0.8	0.8	0.8	0.8

[a] Unless otherwise stated, upper bounds on activities are infinite.

Table B. The optimal strategy

June–September, Stage 1

Winter cauliflower	5.00 acres
Spring cabbage	2.48 "
Early tomato	3.62 "
Spring lettuce	3.59 "
Summer lettuce	0.31 "
Carrot	5.00 "
Glasshouse tomato	1 house

October–January, Stage 2

Branch $e_{1,11}$:

Spring cabbage	2.48 acres
Cucumber	4.69 "
Early tomato	3.62 "
Main tomato	1.38 "
Pumpkin	5.00 "
Spring lettuce	3.59 "
Summer lettuce	0.31 "
Carrot	5.00 "
Glasshouse tomato	1 house

Branch $e_{2,11}$:

Winter cauliflower	2.67 acres
Summer cauliflower	2.33 "
Cucumber	4.88 "
Early tomato	3.62 "
Main tomato	1.38 "
Pumpkin	3.61 "
Spring lettuce	3.59 "
Carrot	4.18 "
Glasshouse tomato	1 house

February–May, Stage 3

Branch $e_{1,12} - e_{4,12}$ (following $e_{1,11}$):

Cucumber	4.69 acres
Early tomato	3.62 "
Main tomato	1.38 "
Pumpkin	5.00 "
Carrot	5.00 "

Branch $e_{5,12}$ (following $e_{1,11}$):

Cucumber	4.69 acres
Early tomato	3.62 "
Main tomato	1.38 "
Pumpkin	4.91 "
Carrot	5.00 "

Branch $e_{1,22} - e_{5,22}$ (following $e_{2,11}$):

Cucumber	4.88 acres
Early tomato	3.62 "
Main tomato	1.38 "
Pumpkin	3.61 "
Carrot	4.18 "

Research Notes

Supervised Credit as a Tool in Agricultural Development*

Dale Colyer and Guillermo Jimenez

This paper reports on a study of a particular supervised credit program in Colombia. The evaluation is made in relation to the achievement of the stated specific goals of the program studied rather than the more global objective of evaluating that particular use of limited development funds vis-à-vis other possibilities or even with respect to the propriety of the stated goals. Thus, the approach taken is to examine a program that has been in operation long enough to judge its achievements as a development tool for small agricultural producers; the evaluation is accomplished by investigating the changes for a group of individual farms through time.

In addition to the usual sources of credit several Colombian public agencies provide farm loan funds, including programs with supervision or technical assistance by at least five agencies (INCORA, *Agrocredito*, *Fondo de Diversificacion*, *Caja Agraria*, and *Fondo de Inversiones Privados*) [8, p. 11]. The program studied is conducted by the Colombian Institute for Agrarian Reform (INCORA), was inaugurated in 1964, and has been financed in part by counterpart funds and AID loans and grants.

For credit program purposes Colombia is divided into regions, each with a regional director and each separated into zones where producers make applications, receive loans, make payments, etc. Field credit supervisors work out of the zone offices, with 4–6 supervisors employed in each zone and around 60 borrowers for each supervisor. The potential borrower, defined as an agricultural producer unable to obtain credit from other sources at reasonable rates, makes application for a loan. Before approval the producer and credit supervisor make a farm and home plan, which includes crops and livestock to be raised, inputs needed, credit requirements, income expected, and repayment schedule. Loans may be made for operating capital, livestock, equipment and machinery, housing improvement, subsistence, and various other purposes [2, p. 7]. More program details can be found in [3, 4].

Control and direction are exercised, basically, through the plan. Certain crops may be discouraged, others promoted; loans for certain purposes disapproved, others encouraged. Loans for some inputs are provided in kind (seeds, fertilizer, pesticides), others in cash (hired labor); technical assistance and advice concerning new or improved technology also are provided. Reports are required and records kept on the progress and development of the borrower's operations. These records can be a valuable research resource and were used in this study to obtain part of the data for analyses of the effects of the supervised credit programs.

The basic purpose of the supervised credit program (SCP) is to induce agricultural development and production and to increase farmers' incomes. Within the study area selected the specific goals, as stated by SCP personnel in the area, were to increase potato production, reduce crop diversification, reduce or eliminate areas planted to some crops considered undesirable in the area (e.g., garlic, corn, wheat), and increase dairy production. It is with respect to these specific goals that this evaluation is undertaken.

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Table 1. Characteristics of average farms included in the study

	SCP		Non-SCP
	1968	1965	1968
Total land (hectares)	8.98	6.90	5.15
Cropland (hectares)	2.70	3.22	1.90
Pastureland (hectares)	4.39	2.92	2.61
Hired labor (pesos)	1933.70	1532.00	1620.00
Machinery (pesos)	5472.60	1448.00	1192.00
Seeds purchased (pesos)	2200.70	1822.00	1392.00
Fertilizer value (pesos)	6525.00	3786.00	2827.00
Pesticide value (pesos)	1447.30	905.00	767.00
Percentage cropland for			
Potatoes	75.0	38.2	45.4
Wheat	8.9	22.0	19.4
Barley	9.2	9.1	4.0
Other	6.9	30.7	31.2
Yield (kgs. per hectare)			
Potatoes	14050	9770	13270
Wheat	1380	1000	1272
Barley	1810	1670	1730
Corn	1110	1310	1110
Fertilizer (pesos per hectare)			
Market prices	2417	556	1480
1965 prices	1750	556	1070

Procedures and Data

Four zones in Boyaca I, a *minifundia* region in the Andean highlands about 60 miles northeast of Bogotá, were used to obtain data for an analysis of the effectiveness of the SCP. Potatoes, wheat, barley, corn, garlic, vegetables, and dairy are the more important agricultural activities of the area. Farms that had participated in the program since its 1965 inception were used to evaluate changes. Of over 1,000 farms participating in 1968, 200 had been 1965 participants; and of these, records of 27 who had participated each year were utilized. Data from SCP records were obtained for these farms. In addition, a survey of the 1968 operations of a random sample of 25 nonparticipants in the same area was used as a check group.[1] Some characteristics of the average farm for each group are shown in Table 1.

Two approaches were used to evaluate the program relative to the stated objectives. An analysis of changes within the sample of participants was made to see if these were significant and corresponded to stated objectives. Total changes in gross farm output were broken into contributive causes in order to determine what portion could have been due to SCP policies by eliminating those changes definitely attributable to other forces. The second approach used was an aggregate production analysis using an unrestricted Cobb-Douglas type of function. Evaluation of the functions and comparisons between years and samples give insights into the effects of the program, overall and relative to stated objectives.

Changes and Comparisons

The average value of crops produced on the sample farms during the four years 1965 to 1968 more than doubled with an increase of 123 percent.[2] Four primary factors were responsible for the change; amount of land cropped per farm, increased prices, changes in the mix of crops produced, and changes in productivity. The net effect of all these except amount of land cropped was to increase the value of crops produced. The period was one of a general inflationary trend in Colombia and although agricultural prices increased less rapidly than others, this still accounted for the largest share of the increase—88 percent. Changes in the output mix accounted for 43 percent and productivity for 33 percent, while the effect of average area cropped per farm was negative and amounted to a −41 percent.[3]

The SCP within the region encompassed less than 4 percent of the producers and therefore could be assumed to have had no effect on prices. The other three factors, however, are susceptible to some degree of control and can be modified by specific policies of the SCP. The program has attempted to attain its objectives through improved productivity and changes in crops produced. Use of fertilizer, pesticides, and improved seeds and production techniques was promoted in order to increase yields. One result was an increase in land planted to potatoes from 38 to 75 percent between 1965 and 1968, while wheat acreage dropped from 22 to 9 percent, barley grown was about a constant percentage, and other crops dropped from about 31 to 9 percent. Average potato yields increased by more than 40 percent and in 1967 were 60 percent higher

[1] About 65,000 farms were in the project area according to the 1960 census of agriculture [1, p. 36]. A random sample of 30 was drawn from those in the area and 25 usable schedules were obtained and used for the non-SCP sample.

[2] The analysis was limited to crop production, which accounted for about 85 percent of the gross value of farm output for the SCP sample in 1968 and toward which most of the SCP efforts to induce changes were directed.

[3] Determination of the relative contribution of each factor was made by a successive assignation of proportion by determining the effects that would have resulted had only one factor varied while holding all others constant.

than 1965 yields; wheat and barley yields were somewhat higher but corn yields slightly smaller.

The average acreage planted to crops declined during the study period, although total acreage per farm increased slightly. Since SCP loans to purchase land are prohibited it is not likely that land per farm would expand as a result of the program, except as a result of higher incomes or release of funds by borrowing for operating expenses. While encouraging expansion of certain cash crops and discouraging excessive crop diversification, program officials also were promoting expansion of dairy and improvement of pasture, a policy which could have resulted in more land for pasture, although dairy production did not increase significantly during the period. Another cause of the decline in land cropped per farm could have been the shift to potatoes, a very labor-intensive crop, especially for the harvest phase. Thus there might have been insufficient labor resources to maintain the same total acreage of harvested crops.

Comparisons of the data with the somewhat smaller farms in the sample of nonparticipants for 1968 indicated that the proportions of crops and yields produced were similar to those of the participants in 1966, better by the criteria of the SCP than the 1965 participant performance but considerably poorer than that for 1968. If the two groups were similar before the program began, the participants have progressed more rapidly or at least have moved significantly in directions promoted by the SCP. Since participants are those who could not obtain adequate credit elsewhere, it may be suspected that they were no better farmers than typical. On the other hand, since participation is voluntary those who used the program may not have been representative either. Because data for nonparticipants is not available for other years, the relative changes cannot be determined. It is not known whether participants changed more rapidly, but it is known that in 1968 their yields and production patterns were markedly different from those of the nonparticipants.

Computed at mean input and values of production, net income comparisons show a substantial increase for the SCP farms even when adjusted for price level changes. The 1968 adjusted net income was about four times greater than in 1965, which was a relatively poor production year. However, the net income in 1968 was about one-third larger than in 1966, although about the same as in 1967 when yields were exceptionally good. The non-SCP sample had 1968 net incomes of about four-fifths the level of SCP sample. Thus, on the basis of available evidence, the SCP seems to have suceeded in Boyaca I.

Production Function Analysis

An unrestricted Cobb-Douglas type of aggregate production function was used with both the participant and nonparticipant samples for a further test of the effectiveness of the SCP policies. Gross value of farm output (crops) was the dependent variable; independent variables were cropland, hired labor (as a proxy for all labor for which data was not available),[4] value of farm equipment, annual operating expenses, and credit. Results for the five estimated equations are summarized in Table 2.

These results indicate again that there is a substantial difference in the SCP and non-SCP samples and, furthermore, that SCP samples varied from year to year. Since there were no strong discernible trends in the coefficients in the four years of the SCP group, it cannot be concluded that the year-to-year variations are due to the SCP policies. Weather or other uncontrollable factors could have caused the observed variations in the coefficients.

One notable distinction between the participants and nonparticipants was the large differences in the coefficients for credit and operating capital.[5] With the exception of the 1967 SCP equation, the coefficients for those variables of the non-SCP samples were larger than the corresponding coefficients of the SCP groups. If the credit were used to effectively increase the amount of inputs per farm, such a result would be expected. While inadequate alone, this evidence when considered with the other analysis tends to confirm the conclusion that

[4] Hired labor can be a relatively good proxy for all labor if the quantity hired is closely and positively correlated with family and other labor inputs. The main use of hired labor on the SCP farm is for potato harvest, and total labor hired is closely related to farm size rather than inversely related to family size. Thus it appears probable that total labor input and hired labor use move together as a function of potatoes planted and harvested. However, this cannot be verified in the absence of data on total labor used.

[5] Frequently credit used is closely associated with operating funds and other input levels, but the simple correlation coefficients between credit and the other inputs were typically about 0.2, except between credit and machinery in two years when the coefficient was about 0.5.

Table 2. Regression coefficients and standard errors for production functions estimated for the SCP and non-SCP samples

Sample	Constant	Regression coefficients and errors					Sum of regression coefficients	R^2
		Land	Labor	Farm equipment	Operating expense	Credit		
SCP-1968	2.899	0.777* (0.196)	0.049 (0.128)	0.048 (0.090)	0.279* (0.147)	−0.084 (0.084)	1.069	.90
SCP-1967	0.658	0.028 (0.290)	0.076 (0.268)	0.258* (0.136)	0.523* (0.215)	0.132 (0.515)	1.017	.78
SCP-1966	1.903	0.108 (0.137)	0.266** (0.162)	0.140** (0.099)	0.282** (0.192)	−0.027 (0.100)	0.769	.64
SCP-1965	1.174	0.379** (0.243)	0.396** (0.269)	0.144 (0.138)	0.314** (0.228)	0.064 (0.073)	1.169	.57
Non-SCP	0.740	0.418* (0.240)	0.456* (0.182)	0.034 (0.096)	0.405* (0.131)	0.104* (0.057)	1.417	.80

* Statistically significant at 5 percent level.
** Statistically significant at 10 percent level.

the credit program has been effective in inducing change, since it is consistent with expectations.

Implications

A basic hypothesis of development economics is that more capital inputs are required both at aggregate and individual producer levels. One of the problems is bridging the gap between the provision of investment funds and their allocation to individual producers. This is especially critical in many rural sections where investment in human capital has lagged and consequently the capacity to effectively utilize resources may be lacking. One way to effect the allocation is through the private sector where the funds will go to those who have the resources and know-how to obtain loans at prevailing rates and can do so because they have proven productive capacity. Such a procedure will of course widen the already large income differences while increasing output, a conclusion that can be verified by examining U. S. agricultural policies.[6]

An alternative is to develop a mechanism for allocating the funds to lower-income, resource-poor agricultural producers. If the funds are to be used effectively, deficiencies in capability probably must be corrected simultaneously. This can be done through separate programs or by a combination of resource augmentation and training, technical assistance, and supervision. Supervised credit programs use the second approach and, as this study indicates, they can, within the limited context considered, induce changes in directions that are felt to be desirable.

[6] It should be noted that U. S. Extension and other farm programs have concentrated almost exclusively on larger, commercial farmers. It was assumed that economic growth would take care of poverty but is now abundantly clear that such is not the case [6, 9].

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Export Supply and Demand for U. S. Cattle Hides*

Paul L. Farris

The supply of U. S. cattle hides increased substantially as beef production rose following World War II. Foreign market outlets absorbed the growing supply, and cattle hide sales abroad climbed to $132 million in 1969. Net exports rose from 4.6 million hides in 1956 to 15.1 million in 1969. Total domestic utilization fluctuated within a relatively narrow range between 19 and 23 million hides per year. Man-made substitutes accounted for a rising share of the U. S. leather market [5] and shoe imports also rose sharply. The price of hides varied considerably during the period, but no persistent long-time trend was apparent.

This paper reports the results of a study examining factors affecting U. S. cattle hide exports for 1956–1969. Statistical estimates of export supply and demand relations were derived, based on hypothesized economic characteristics of the commodity.

Economic Considerations

Hides are a by-product of beef production, the quantity forthcoming being determined by the number of cattle slaughtered. The price of hides has no perceptible influence on the quantity produced. Demand for cattle hides is determined chiefly by population, income, substitutes, preferences for leather products, and changes in consumption habits over time. Purchasing power is influenced by the strength of the economy; substitutes and preferences are associated with technological developments, new products from alternative raw materials, and changes in cultural habits affecting consumption.

Exports and imports of cattle hides have been influenced predominantly by relative supplies and demands around the world. U. S. sales abroad have been little affected by restrictive barriers of particular countries, aside from general policies affecting trade between the U. S. and Communist nations. Hide export controls and import quotas were imposed only briefly by the United States, between March and October 1966. U. S. cattle hides have been marketed in many countries, the more important being Japan and members of the European Common Market. The United States and Argentina have been the principal world suppliers, accounting for around three-fifths of cattle hides entering foreign trade channels during recent years.

Theoretical Model

Export supply and demand for U. S. cattle hides can be conceptualized within a two-region trade model [4, p. 286]. The United States can be considered as one region and the rest of the world the other. Within each region the supply of cattle hides is hypothesized to be completely inelastic with respect to price. The quantity demanded within each region, after allowing for the effects of changes in purchasing power, substitutes, and the like, is hypothesized to have some price responsiveness. Since U. S. hide exports have exceeded imports each year during the period, it is implied that in the absence of trade the equilibrium price of cattle hides in the United States would have been lower than the equilibrium price in the rest of the world by more than transport costs. There has been an excess supply function of hides in the United States, in which quantity and price are assumed to have been positively related, and an excess demand function for U. S. hides in the rest of the world, in which quantity and price are assumed to have been inversely related.

The excess supply, that is, the quantity of U. S. cattle hides available for export in any given year, is assumed to be determined largely by the quantity of beef produced, the strength of U. S. demand for hides, and the U. S. price of hides. Foreign excess demand for U. S. hides is believed to be strongly influenced by production in countries outside of the United States, by the strength of foreign demand for hides, and by the U. S. price of hides.

The quantity exported from the United States and U. S. price tend to be jointly determined within an international market setting. A simultaneous system is implied in which joint solution of a demand equation and a supply equation is necessary to estimate U. S. export

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supply and demand relationships. Endogenous variables are U. S. price and U. S. export volume. Important exogenous variables, assumed to be determined outside the hypothesized system, include U. S. and foreign hide production, purchasing power, changes over time in preferences, and trends in the price, quality, and availability of substitutes for hides and leather products.

Empirical Model and Data

An empirical model was developed taking into account both the postulated economic relations and the nature of the data available. The model consisted of two functional relations and the equilibrium identity, as follows:

(1) Demand: $E_d = f(P, S_f, T, E_1)$
(2) Supply: $E_s = f(P, Sd, Dd, T, E_2)$
(3) Equilibrium identity: $Ed = Es$

where the endogenous variables were

E_d = export demand for U. S. cattle hides,
E_s = export supply of U. S. cattle hides,
P = price of cattle hides,

and exogenous variables were

Sf = production of cattle hides abroad,
Sd = production of cattle hides in the United States,
Dd = purchasing power in the United States,
T = time, and
E_1 and E_2 = error terms for equations (1) and (2) respectively.

Equation (1) was overidentified and equation (2) was just identified.[1] The model was therefore identified, provided that the coefficients of the exogenous variables were not zero in equations (1) and (2).

In the demand equation it was expected that price and foreign supplies were inversely associated and time was positively associated with exports. In the supply equation it was expected that price, U. S. hide production, and time were positively associated with exports, while U. S. purchasing power was inversely associated with exports.

Several decisions and assumptions were involved in selecting data for the model. A beginning consideration involved length and specification of the observation period. Foreign production data were available only on an annual, calendar year basis. No strong reason appeared for using other than calendar year observations. Yearly observations averaged out seasonal patterns, which may have complicated the use of shorter periods.

Data were obtained for the 14-year span, 1956 through 1969, which covered at least one complete cattle cycle in the United States, from a peak in number slaughtered in 1956 to the recent high in 1969. The data series represented economic forces at the wholesale level. The U. S. cattle hide price index was used to represent the U. S. price. It was deflated by the BLS Wholesale Price Index as a means of adjusting for general price level changes. U. S. purchasing power was represented by Gross National Product in constant 1958 dollars. Although GNP contains a large proportion of goods and services measured at the final-product level, it was believed that this aggregate measure of domestic purchasing power appropriately indicated composite U. S. demand forces for cattle hides. Time was included as a proxy for variables that seemed to have changed consistently over time and for which alternative data series were not available. The most important components of the time variable were believed to be effects of changes in U. S. preferences and substitutes in the supply equation and similar foreign influences plus aggregate foreign income changes in the demand equation. The series were not put on a per capita basis because of inadequate foreign population data.

Foreign hide supplies were represented by estimates of beef and veal production for 42 countries, excluding the United States. These were the foreign countries for which beef and veal production estimates were available and the major commercial countries abroad. They accounted for about 35 percent of world population and 48 percent of the arable land in the early 1960's. Important exclusions were India, Pakistan, Mainland China, and other parts of Asia and Africa. The complete data series used in the analysis are presented in Table 1.

Some of the series undoubtedly were inaccurate proxies for the economic factors they were used to represent; a great deal of aggregation was involved; not all important explanatory variables may have been included; and the forms of the relationships may not all have been linear. The analysis is therefore exploratory, and results are only suggestive of relationships that might be discovered with more complete data.

[1] According to procedures for identification outlined in [1, p. 380].

Table 1. Time series data used to estimate export demand and supply relationships for U. S. cattle hides

Year	Dd	Sd	Sf	T	P	Ed=Es	Q(U. S.)
	U. S. GNP in 1958 dollars	U. S. cattle hide supply[a]	Foreign cattle hide supply[b]	Time	Cattle hide wholesale price index deflated[c]	Net U. S. exports of cattle hides[d]	U. S. utilization of hides
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	billion dollars	*million head*	*billion pounds*			*million*	*million*
1956	446.1	27.8	33.0	56	88.9	4.6	23.2
1957	452.5	27.0	34.1	57	79.4	6.4	20.7
1958	447.3	24.4	35.3	58	80.6	5.0	19.4
1959	475.9	23.7	33.4	59	139.7	3.1	20.7
1960	487.7	26.0	35.2	60	96.5	6.6	19.5
1961	497.2	26.5	37.0	61	104.8	7.4	19.1
1962	529.8	26.9	40.0	62	105.4	6.7	20.2
1963	551.0	28.1	41.7	63	75.3	7.6	20.5
1964	581.1	31.7	40.1	64	69.7	11.2	20.5
1965	617.8	33.2	41.2	65	94.3	13.0	20.2
1966	658.1	34.2	43.4	66	117.5	14.1	20.1
1967	675.2	34.3	45.7	67	78.0	12.5	21.8
1968	707.2	35.4	47.5	68	71.1	13.1	22.3
1969	727.1	35.6	48.3	69	87.8	15.1	20.5

[a] Total number of U. S. cattle slaughtered.
[b] Beef and veal production in billion pounds.
[c] Annual average BLS wholesale price index (1957–1959=100) for cattle hides (04–11) deflated by annual average BLS wholesale price index for all commodities (1957–1959=100). The cattle hides grouping accounted for less than .1 percent of the relative importance of all commodities in the wholesale price index.
[d] Total exports minus total imports in millions of hides.

Sources: Column 1: *Economic Indicators* [2].
Column 2: *Livestock and Meat Situation* [6].
Column 3: *World Agricultural Production and Trade Statistical Report* [8].
Column 5: BLS Wholesale Price Index [9].
Column 6: *Livestock and Meat Situation* [6] and *U. S. Foreign Agricultural Trade by Commodities* [7].
Column 7: Column 2 minus column 6.

Results

Two-stage least squares (2SLS) and three-stage least squares (3SLS) procedures were used to estimate the parameters of the postulated demand and supply relations. Ordinary least squares (OLS) estimates were also derived for comparison with the simultaneous system estimates. Results obtained by each method are presented in Table 2.

The signs of the coefficients in the demand and supply equations were all consistent with expectations. The growing foreign market for U. S. cattle hides was reflected in the positive coefficient of the time variable in both demand and supply equations. In the demand equation foreign hide production and price were both inversely associated with U. S. exports. In the supply equations exports were strongly associated with U. S. cattle slaughter. Exports were inversely associated with U. S. purchasing power and positively associated with price.

The estimated coefficients obtained in the two- and three-stage methods were the same for the demand equation.[2] The price elasticity of foreign demand for U. S. hides computed at the means was about −.8. However, the demand estimates using ordinary least squares differed and are believed to be less indicative of structural relationships.

All three estimation methods for the supply relation gave similar results. The coefficients for the price variable indicated that quantities available for export were not strongly associated with price. The price elasticity coefficients computed at means were around .15, but the standard errors were larger than the coefficients.

These results imply that if the strongly expanding foreign market for cattle hides had not existed during the recent period of rapidly increasing U. S. beef production, the price of cattle hides in the United States would have been sharply lower. Given the expectation of

[2] Inasmuch as the supply equation was just identified, it did not improve the efficiency of third-stage estimation of the demand equation [3, p. 352].

Table 2. Statistical estimates of relations between U. S. cattle hide exports and hypothesized explanatory variables

Equation	Estimation method	Dependent variable	Constant	Explanatory variables						R^2	d[b]
				Dd	Sd	T	Sf	$\hat{P}$[a]	P		
Reduced form	OLS	P	385.620 (1.50)[c]	.941 (2.58)	−9.773 (−2.85)	−2.119 (− .336)	−10.067 (−3.06)			.660	1.87
Demand	2SLS	Ed	−59.091 (3.19)			1.671 (2.42)	− .721 (−1.23)	−.083 (1.76)		.828	
Demand	3SLS	Ed	−59.091 (3.19)			1.671 (2.42)	−.721 (−1.23)	−.083 (1.76)			
Demand	OLS	Ed	−50.992 (3.29)			1.190 (2.24)	−.284 (−.64)		−.033 (1.15)	.868	1.26
Supply	2SLS	Es	−66.144 (−3.52)	−.052 (−2.06)	1.127 (4.02)	1.115 (2.72)		.017 (.84)		.968	
Supply	3SLS	Es	−69.829 (−3.73)	−.055 (−2.18)	1.050 (3.79)	1.241 (3.08)		.012 (.59)			
Supply	OLS	Es	−65.215 (−3.74)	−.051 (−2.16)	1.110 (4.44)	1.100 (2.80)			.015 (1.04)	.968	2.00

[a] Coefficients in 2SLS and 3SLS were obtained using the price series predicted by the reduced-form equation.
[b] The Durbin-Watson statistic indicated absence of serial correlation in the residuals for the reduced-form equation and the supply equation estimated by OLS; it was inconclusive for the demand equation estimated by OLS.
[c] *t* values in parentheses.

further increases in U. S. beef production in the years ahead, price prospects for U. S. cattle hides will depend importantly on the future strength of foreign demand and on the unrestricted flow of U. S. hides into world markets. The findings of this study may be useful in assessing future export and price relationships insofar as economic conditions in the years ahead resemble those of the period studied.

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Managerial Socioeconomic Characteristics and Size of Operation in Beef Cattle Feeding—An Application of Discriminant Analysis*

A. A. ARAJI AND R. M. FINLEY

PREVIOUS STUDIES pertaining to size of operation have claimed that significant cost savings are associated with size in beef cattle feeding [6, 8, 10, 11, 12, 17]. However, these studies considered only the physical factors associated with the production and marketing of beef, completely ignoring managerial ability and its probable effect on size of operation. Real or imaginary, the internal and external cost-savings factors associated with size have been considered the incentive for the increase in size of feedlots [16]. Other studies have indicated that willingness to assume risk and uncertainty and possession of scientific and economic know-how characterize the managers of large-size feeding operations [4, 5, 13]. These studies suggest that a large-size feedlot is not necessarily only a product of internal and external factors associated with size but that it is also affected by the socioeconomic characteristics of the managerial input.

The dilemma faced by economists studying economies of scale may involve violation of the ceteris paribus conditions; the analysis fails to hold everything except for scale constant. If the socioeconomic characteristics of management are related to size of operation, the phenomenon that some studies identified as economies of scale may not be true economies of scale but simply a reflection of the superior managerial capabilities of the large-size operator. However, the extent to which the manager's socioeconomic characteristics are related to size—that is, the extent to which ceteris paribus conditions are violated—has not been quantified or empirically tested.

In this paper indices are developed to measure the socioeconomic characteristics of feedlot managers as related to size. Discriminant analysis is used to test the hypothesis that operators of various sizes differ significantly with respect to their socioeconomic characteristics.

Method and Study Area

A stratified random sample of cattle feeders in Missouri was interviewed in an attempt to determine whether cattle feeders in various size-groups differ significantly with respect to their socioeconomic characteristics. Cattle feeders were stratified by size of operation, and a random sample was proportionally drawn from each stratum. A 100 percent response was obtained.

The following criteria (developed by Hobbs [9] in consultation with a panel of psychologists and sociologists) were adopted in this study to measure the operator's attitudes toward risk, science, economics, and independence in making decisions.

Risk aversion: the degree to which the manager is oriented toward security and conservatism, that is, whether or not he is reluctant to make decisions perceived as involving the element of risk and uncertainty.

Economic motivation: the degree to which the farm manager values economic ends and the degree to which occupational "success" is defined by economic criteria.

Scientific orientation: the degree to which the manager is positive in his attitude toward science and the use of scientific method in decision-making.

Independence: the degree to which the manager positively values independence in decision-making and the degree to which he is willing to deviate from neighborhood norms.

Managers were asked to respond to a number of questions relating to each criterion.[1] For statistical analysis a coding procedure was developed to quantify their verbal responses:

Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1	3	4	5	7

The spread in scoring between 1 and 3 and 5 and

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[1] For complete listing of questions included in each criterion, see [2].

7 was adopted as a method to homogenize the variance of the subject's response on individual items and on total scores. The total score for each manager was computed for each of the four sets of items. The greater his total score for any one of these sets, the greater value he is assumed to place on that criterion.

The Model

Since the work of R. A. Fisher in the thirties the technique of discriminant analysis has been modified for application to more than two-groups classification [14, pp. 237–258; 1, pp. 147–152]. While the technique has been frequently used in biometric research, its application in economic research has been limited to two-groups classification as originally developed by Fisher. A survey of literature on Fisher's discriminant function and its applications to economic problems may be found in Tintner's application of multivariate analysis to economic data [15]. Blood and Baker [3] applied Fisher's discriminant function to classify production situations in Northern Great Plains into wheat production and range forage production. They computed the linear discriminant function, Z, and used analysis of variance of Z between and within groups for test of significance. They also compared this result with results obtained from the application of linear multiple regression and linear probability functions.

Discriminant analysis as applied in this paper links the problem of discriminating between more than two groups, the test of significance, and the associated probability estimates in one methodological procedure. Its kinship with analysis of variance is rather obvious since both deal with data that can be classified into discrete categories. Analysis of variance relates outcomes (a continuous variable) to discrete categories of treatments and shows whether the treatments are significantly different with respect to that variable. Discriminant analysis is conceptually the inverse, relating discrete categories of results to continuous treatment variables in order to show whether the discrete categories are significantly different with respect to the combined effect of the treatment variables.

In our case the discrete categories are four size-groups of cattle feeders:

K_1 is size category with feeding capacity at any one feeding period of 35–99 head;[2]
K_2 is size category with feeding capacity at any one feeding period of 100–199 head;
K_3 is size category with feeding capacity at any one feeding period of 200–399 head; and
K_4 is size category with feeding capacity at any one feeding period of 400–10,000 head.[3]

The treatment variables are the following eight indices measuring each operator's socioeconomic characteristics:

x_1 is the number of years of formal education the manager completed;
x_2 is the age of the manager;
x_3 is the manager's risk aversion;
x_4 is the manager's scientific orientation;
x_5 is the manager's independence;
x_6 is the manager's economic motivation;
x_7 is the income distribution preferred by the manager during the year; and
x_8 is the percentage of the feeding operation owned by others.

Results

The group means and the common means for each socioeconomic index are shown in Table 1. The generalized Mahalanobis D^2 statistic, γ, is used as chi-square with $m(g-1)$ degree of freedom to test the significance of differences among the mean values of g size-groups for the m socioeconomic variables.[4] The computed value of γ is 314.49 which is significant at $P \leq .01$, indicating that the four size-groups, and any pairs of them, do differ significantly in the specified characteristics, though not necessarily in each characteristic tested singly.

[2] Operators with feeding capacity below 35 head were excluded from the study on the basis that their beef enterprise did not constitute a significant portion of their farm income.

[3] The lower boundary of 400 head was chosen on the assumption that 2.5 is an average annual turnover and that annual production of 1000 head and over is considered a large feeding operation. Farmer-feeders were defined as those operators with under 1000 head capacity at the end of each year.

[4] The generalized Mahalanobis D^2 statistic is

$$\gamma = \sum_{i=1}^{m} \sum_{j=1}^{m} \lambda_{ij} \sum_{k=1}^{g} n_k(\bar{x}_{ik} - \overline{X}_i)(\bar{x}_{jk} - \overline{X}_j)$$

where

$i, j = 1, 2, \ldots, m$ are the socio-economic variables;
$k = 1, 2, \ldots, g$ are the size of operation groupings;
λ_{ij} = the i, jth element of the pooled dispersion matrix;
n_k = sample size in the kth group;
$\bar{x}_{ik}$ = the mean of the ith variable in the kth group; and
$\overline{X}_i$ = the overall mean of the ith variable.

Table 1. Group means and the common means for each socioeconomic index

Size categories	Sample size	Mean values							
		Education	Age	Risk aversion	Scientific orientation	Independence	Economic motivation	Income distribution	Ownership
K_1	28	11.28	49.57	55.03	66.82	69.68	56.36	3.25	1.17
K_2	22	12.18	48.23	58.00	70.77	74.23	59.70	3.09	10.77
K_3	13	11.77	44.54	60.54	76.54	75.46	65.46	3.23	21.61
K_4	12	13.75	48.75	70.42	80.42	74.92	70.58	3.33	56.58
Common mean		12.03	48.17	59.32	71.84	72.85	61.16	3.21	16.40

This result does not specify where significant differences occur nor whether the groups differ significantly in each of the socioeconomic characteristics. Duncan's multiple range test [7] is used to compare the mean value of each socioeconomic variable in one size-group with its mean value in all other size-groups. Table 2 shows where these means differ significantly.

Interpretation of the Duncan results

The Duncan test results indicate that managers in size-group four are significantly different from managers in size-groups one, two, and three in education, risk aversion, scientific orientation, economic motivation, and type of ownership. More specifically, it appears that managers in size-group four (1) have completed more years of formal education; (2) are more willing to accept risk; (3) are more scientifically oriented; (4) are more economically motivated; and (5) have larger proportions of their feeding operation owned by others. Managers in size-group four are also significantly more independent in making decisions than managers in size-group one. Similarly, indications are that managers in size-group three relative to those in size-group one (1) are less oriented toward risk aversion; (2) are more scientifically oriented; (3) are more economically motivated; (4) are more independent in making decisions; and (5) have a higher percentage of their feeding operation owned by others.

The individual analyses of the socioeconomic factors showed no significant difference between groups one and two with respect to any of the variables; but groups two and three were significantly different with respect to two variables only, scientific orientation and economic motivation. However, such individual analyses and their indication of the relative importance of factors are sometimes misleading. There is an effective linear combination of factors that distinguished successfully between the pairs of groups. The results of the discriminant analysis for two-groups classification indicates that these pair groups are significantly different with respect to the total effect of the socioeconomic factors. The computed value of γ for groups one and two is 32.87 and for groups two and three is 27.23, both of which are significant at $P \leq .01$.

Other implications

Discriminant analysis was used to classify observations according to the size category that their socioeconomic characteristics would seem to fit. A set of linear discriminant functions were obtained to serve as indices for classifying an individual manager into K groups and estimating the probability of his being associated

Table 2. Mean comparison of the socioeconomic variables with respect to size-groups

Groups compared	Means							
	Education	Age	Risk aversion	Scientific orientation	Independence	Economic motivation	Income distribution	Ownership
K_1 vs K_2								
K_1 vs K_3			*	*	*	*		*
K_1 vs K_4	*		*	*	*	*		*
K_2 vs K_3				*		*		
K_2 vs K_4	*		*	*		*		*
K_3 vs K_4	*		*			*		*

* Significant at $P \leq .01$; lowering the probability level to $P \leq .10$ did not change the outcome.

with the suggested size-group. It is of interest to note that all observations in size-group four show a high probability of association with the discriminant function 4, implying a higher degree of homogeneity in socioeconomic characteristics than observations in the other size groups.

Conclusions

While economies of size may be an incentive for increasing the size of feedlot, it is not the sole criterion. Large-size feedlots require managerial input with socioeconomic characteristics compatible with large-size operation. Managers of large-size feeding operations demonstrate a common socioeconomic behavior that definitely distinguishes them from the farmer-feeders. Their managerial behavior is characterized by willingness to accept a higher degree of risk, appreciation for and application of scientific and economic criteria in decision-making, higher level of formal education, and willingness to accept a lesser degree of ownership. Farmer-feeders, on the other hand, seem to place higher value on risk aversion and sole ownership ("being my own boss"). They are also less economically and scientifically oriented and have less formal education. In general, significant differences are apparent between managers of the four-size groups considered in this study with respect to combined effect of their socioeconomic characteristics.

Results of this study show that size of operation is related to managerial socioeconomic characteristics. Economies-of-scale studies that ignore this relation err by failing to hold constant everything except for the aspect of scale being studied. If socioeconomic characteristics of management are related to size, as indicated here, then research suggesting economies of size in beef cattle feeding may be reflecting only the superior management of such units.

Although discriminant analysis has been applied only to cattle feeders in this study, it has a wide application in social science research, especially where human factors are involved and where the combined effect of a set of factors is more relevant than the effect of each factor alone. In general, discriminant analysis permits the investigator to weigh several factors according to their importance and to allow for interrelationship between factors, a job which is done imperfectly by analysis of variance or regressions with dummy variables.

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Obtaining Preliminary Bayesian Estimates of the Value of a Weather Forecast

JOHN P. DOLL

APPLICATION OF Bayesian decision theory to problems facing agriculture has come during a decade of continually increasing interest in the weather [12]. The National Weather Service spends about 70 million dollars annually observing, analyzing, and forecasting weather phenomena. In addition to the usual general forecasts, specialized forecasts of particular value in local areas are used in agriculture as well as other industries [13, p. 86]. In the future forecasts of specific weather phenomena will undoubtedly become increasingly available, either as a public service from the Weather Service or for sale by private consulting firms.

The public forecasting service would want to avoid the cost of issuing forecasts that cannot profitably be used by the clientele in the forecast area. Or farmers purchasing private forecasts would want to avoid paying a price that exceeds their value. Thus, as the capability of issuing forecasts increases, it seems reasonable to assume that agricultural economists will be called upon to estimate their value.

The Bayesian decision model would seem to be suited to the task of estimating the value of weather forecasts. The model itself has been extensively developed in the literature [5, ch. 5 and 6; 9; 11, ch. 5; 14; 15]. Its use in price forecasting has been demonstrated by Eidman, Dean, and Carter [7] and Bullock and Logan [1]. Carlson [4] illustrated its use for crop disease forecasting. Byerlee [2] and Byerlee and Anderson [3] have used it to evaluate a long-range weather forecast.

Estimates of the production function, the prior probability distribution for weather inputs, and the likelihood function are needed to compute the value of a forecast. The production function would include the random weather variables to be forecast as well as a set of inputs under the manager's control. It would be used to compute the profits from alternative actions and suggest the form of the forecast.

Unfortunately, when using Bayesian analysis the information needed to estimate the value of the forecast is the same information needed to implement it and, as such, may not be available. Given this lack, a realistic approach at the initial stages of research would be to ask: Will the value of the forecast be sufficient to justify the research and development costs of making the forecast operational? This would entail developing the forecast technology as well as reliable estimates of the production function and the prior distribution.

In the complete absence of data the researcher can do nothing except suggest the nature and extent of the required research. But if part of the needed data exists, a preliminary analysis may be possible. For example, if some knowledge of the production function is available, initial estimates of the value of the forecast can be obtained by assuming "reasonable" prior probability density functions and likelihood functions. A sensitivity analysis will then determine the effects of alternative estimates for these density functions and suggest limits within which forecast accuracy and the value of the forecast might fall.

Forecasting Weather Affecting Corn Production

Description of problem and initial findings

The problem of forecasting the growing season for corn in Missouri for the purpose of determining the optimum amount of applied nitrogen and number of plants per acre is considered as an example. A forecast of weather during a forthcoming growing season would have many uses, but for this example the farmer uses it to make a decision about fertilization and planting rates. The meteorologist is thus concerned with the forecast of a set of weather variables that would be substituted as arguments into a production function used to derive economic optima. While a formidable task, given existing forecasting techniques, the problem is suited to the purpose of this paper: First, the production functions relating corn yields to relevant weather variables are not known. While corn yield varies as a function of rainfall, temperature, planting date, and a host of other climatic variables, reliable estimates of the effects of these variables are not available and could be determined only by a

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definitive (and costly) experimental process. Second, in the absence of knowledge of the exact variables affecting yields, "objective" priors cannot be derived from weather records. Finally, of course, the meteorologist cannot forecast variables known only in general.

As in many cases of this nature, partial information of value is available. Colyer and Kroth have presented production functions for corn at three locations in central Missouri.[1] The functions were estimated using least squares regression from corn yield data collected from controlled experiments using seven rates of applied nitrogen and four levels of plant population arrayed in a complete factorial. The estimated production functions were quadratic in each variable; all resulted in satisfactory fits; and all displayed diminishing marginal productivity.[2] There were seven years of data at each location, and a production function was estimated separately for each year.

In an initial approach to the problem, each production function can be regarded as representing a state of nature, where "nature" is assumed to be that set of weather variables determining corn yield response to applied nitrogen and plant population. The estimated production functions are in fact estimates of "subproduction" functions that characterize yield response to known variables within a year and to unknown weather variables among years.[3] The seven production functions for a location provide information that can be used to estimate the profits resulting from the selection of a particular action (nitrogen and plant population rates).

Initially an equally likely prior distribution was assumed; each growing season was assigned a prior probability of 1/7. This limits the estimated value of the forecast to the seven years that actually occurred. As is too often the case in weather research, this sample is small in the classical sense. But one advantage of the Bayesian analysis for this type of problem is that the priors can be varied. A sensitivity analysis of the priors will be presented below.

The likelihood function is the method by which the accuracy of the forecast can be adjusted. Seven forecasts were assumed, one for each of the seven possible growing seasons. The probability that a state of nature would be forecast, given that it was in fact the true state, was arbitrarily increased from 1/7 (no information) to 7/7 (perfect forecast) through discrete intervals of 1/7. In each case the remaining probability was equally divided among the other six states of nature.

Given the data described above, the straightforward Bayesian algorithm was applied. Profit functions, net of the direct costs of nitrogen and plant population, were computed assuming that corn was valued at $1.00 per bushel, nitrogen at 11 cents per pound and plant population at 15 cents per thousand. The prior or posterior expected profit functions were derived from the annual production functions. The expected profit functions were then maximized with respect to nitrogen and plant population to obtain the prior or posterior optimal action. The value of all forecasts of a given accuracy, say 2/7 or 3/7, were determined as described by Byerlee and Anderson [3].

The results for three locations in central Missouri are presented in Table 1 for seven levels of forecast accuracy. Although the numbers differ for each county, the findings are in general quite similar. With one exception, marginal returns to forecast accuracy are increasing. Returns to forecasting are very small for low levels of accuracy and increase to above $1.00 only as forecast accuracy rises about 50 percent. In each case the highest marginal in-

[1] A portion of the data may be found in Colyer and Kroth [6] and the remainder obtained directly from them.

[2] One function for Grundy County showed diminishing returns to each input but increasing returns out any isocline. The function was almost linear and therefore the assumed optimum for that year was set at the maximum rate included in the experiments.

[3] The analysis is based on the assumption that all among-year variations in the seven production functions are due to variations in weather variables. However, the production functions estimated for each year are single-valued estimates of the true response function for the year. Even if identical weather conditions had occurred each year, a distribution of response functions could have been obtained. Thus, in the above analysis, among-year weather effects are confounded with within-year variations in response. The magnitude of each source of variation can be determined only by a complete determination of the production function.

Assuming no knowledge of the factors causing the production function to vary among years, the values obtained in the analysis could be viewed as simply the value of general information about the production function. When the value of such a "forecast" is extremely small, additional investigation into the variations among annual production functions is not warranted, regardless of the cause. When the value of the forecast becomes large enough to be of interest, further analyses would have to be conducted to determine the effects of within-year response variations. If within-year variations are important they could either increase or decrease the value of the forecast, depending on whether they offset or augment among-year variations.

Table 1. Value of a forecast of the growing season for corn for three locations in North Central Missouri assuming a uniform prior distribution (dollars per acre)

Forecast accuracy	Saline County 1962–1968		Grundy County 1962–1968		Boone County 1963–1969	
	Total value	Marginal value	Total value	Marginal value	Total value	Marginal value
1/7	0.00	—	0.00	—	0.00	—
2/7	0.07	0.07	0.22	0.22	0.16	0.16
3/7	0.25	0.18	0.89	0.67	0.59	0.43
4/7	0.66	0.41	1.97	1.08	1.45	0.86
5/7	1.32	0.66	2.59	0.62	2.81	1.36
6/7	2.42	1.10	3.98	1.39	4.79	1.98
7/7	4.02	1.60	5.69	1.71	7.04	2.25

crement from increasing forecast accuracy results from the increase from 6/7 to 7/7.

The high level of accuracy needed, plus the presence of increasing marginal returns, suggests that if the forecast is to be made at all it must be quite accurate. Given this information, the meteorologist could begin to determine the feasibility and development costs for the forecast.

The value of the forecast may have to be aggregated for a group of users. In each such case the geographical area of relevance for a particular forecast would have to be determined. If a county were a reasonable forecast area, then for purposes of fertilizer decisions the value of a forecast of accuracy 4/7 would be $66 thousand for Saline County (99,500 acres), $76 thousand for Grundy County (38,600 acres) and $43 thousand for Boone County (29,800 acres). The value of a perfect predictor would be much higher—$400 thousand, $220 thousand and $209 thousand for Saline, Grundy, and Boone Counties, respectively.

These estimates assume uniform priors for all producers and that the increased output in these counties will not affect input and output prices. In general, neither may be the case. Lave's analysis [10] examines aggregate price effects. Specialized weather forecasts of this type might be issued for users in small areas in which aggregate price effects are not significant, but other aggregation problems exist. For a given area aggregation would always necessitate some assumptions about the relative efficiency of producers, but in the Bayesian case it also presumes knowledge of producers' subjective priors. When priors differ the analysis would have to be repeated for each prior and then values weighted and aggregated. An interview technique similar to Carlson's [4] might be needed to establish a distribution of priors.

A group of farmers purchasing a forecast for a specialized use would be concerned with estimating the aggregate value of the forecast to their group. Most weather forecasts would undoubtedly have multiple uses to a farm manager, in which case the value in each use would have to be assessed and total value determined for each farm. A public forecast of course would be available to all users; evaluation of the benefits would be more complex and would involve problems similar in nature to the evaluation of other public investment projects.

Table 2. Value of a weather forecast for four alternative priors, Saline County, Missouri, 1962–1968

	Equally likely	Central tendency	Extreme year I	Extreme year II
Year	Assumed prior distributions			
1962	1/7	1/14	3/35	1/35
1963	1/7	1/14	10/35	15/35
1964	1/7	3/14	3/35	1/35
1965	1/7	3/14	3/35	1/35
1966	1/7	4/14	3/35	1/35
1967	1/7	1/14	3/35	1/35
1968	1/7	1/14	10/35	15/35
Forecast accuracy	Value for each level of forecast accuracy for the above prior distributions (dollars)			
1/7	0.00	0.00	0.00	0.00
2/7	0.07	0.05	0.15	0.34
3/7	0.25	0.13	0.57	1.17
4/7	0.66	0.36	1.38	2.52
5/7	1.32	0.71	2.60	4.22
6/7	2.42	1.30	4.21	5.99
7/7	4.02	2.54	5.96	7.86

A sensitivity analysis of the priors

Hildreth [8] has discussed the fact that different users may have different priors and suggested that the analysis be repeated for reasonable priors. In the initial stages of a forecast evaluation a variety of priors might be used to determine the sensitivity of the solution to the prior distribution.

As an example, the prior probability distributions for the Saline County experiments were adjusted in two different ways (Table 2). First, "central tendency" prior distributions were derived assuming the middle years of the sample occur more frequently than the extreme years. Second, because the value of the forecast could be expected to increase as the probabilities of the extreme years increase, two ex-

treme distributions were developed, one (I) assigning the extreme years a probability 10/35 and the other (II) assigning the extreme years a probability 15/35, with the other five years assigned equal probabilities. The distributions in Table 2 were based upon a classification of the annual optima for the Saline County experiment.[4]

Results of varying prior distributions on the value of the forecast are also presented in Table 2. Compared to the uniform prior, the central tendency prior weights heavily the middle or average years and thus reduces the value of the forecast. For this prior distribution a perfect forecast is worth \$2.54, \$1.48 per acre less than that for the equally likely distribution. As the weights on the extremes are increased the value of the forecast increases. When the extremes are weighted to the highest proportions (extreme year II), the value of the forecast increases to \$7.86 per acre for the perfect forecast. Presumably, some users might have a subjective distribution of this type, but the high frequency of extremes would (subjectively) seem unreasonable for central Missouri.

Varying the priors does affect the required forecast accuracy. The accuracy needed to return \$1.00 per acre drops from 5/7 for the central tendency prior to 3/7 for extreme prior II. Thus the value of the forecast increases for the farmer whose prior beliefs are extreme.[5] Also, some bounds are placed on the possible value as accuracy increases to one. For a given level of accuracy, if the cost of issuing the forecast is less than the benefits resulting from the central tendency prior, research should proceed because these estimates appear to be conservative. But if the cost of issuing the forecast would exceed benefits computed on the basis of the prior distributions for the extreme years, additional research into the possibility of issuing the forecast would appear of questionable value. If the cost of the forecast is between these two bounds, additional investigation of possible prior distributions of users is warranted.

A similar sensitivity analysis for the likelihood function suggested that as the generality of the forecast increases the forecast accuracy needed to achieve a given value also increases. Marginal returns to accuracy for general forecasts were still increasing but the increments were smaller and the value of perfect forecasts were reduced.

[4] Data are not included in the interest of brevity. Alternative distributions based upon profits resulting from optimal actions were also used, but the results did not differ appreciably from those presented.

[5] This is true when at least two extreme states of nature are considered highly probable. When a user's subjective belief in the probable occurrence of a particular state of nature is one, the forecast has no value to him, even if it is 100 percent accurate.

Summary Remarks

The proper time to assess the value of a forecast is before it is made operational. Although forecasting the growing season for corn is impossible at the present time, it was possible to estimate rough bounds for the needed accuracy and the resulting values. Such bounds will be useful when determining the feasibility of further research into the forecasting problem.

When subproduction functions relating output to controlled inputs are available, the analysis in this paper can be followed. In other cases the prior distribution and the likelihood function might be known and the production function unknown. The sensitivity analysis could then be performed using assumed production functions. The discrete analysis described by Ying [16] could be useful for such analyses.

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EDITOR'S NOTE: This section of the *American Journal of Agricultural Economics* may include comments on the replies to previous articles and other literature in agricultural economics, suggestions for improving the effectiveness of the AAEA, discussions of changes in emphasis needed within the profession, and contributions on other topics of interest and importance to agricultural economists. Manuscripts submitted for this section should be prepared in accordance with the guide appearing on the inside of the back cover of this issue and should not exceed 1,000 words.

Communications

EMERGING PRIORITIES IN THE TRAINING AND RESEARCH ORIENTATION OF AGRICULTURAL ECONOMISTS

The crux of the issue lies in the contrast between conditionally normative projections on the one hand and real world predictions on the other. Agricultural economics becomes an ever more powerful "projector" of economic outcomes given the determinative premises of the economic man and the specification of an uncomplex criterion. It becomes little if any better as a predictor of real world outcomes from economic processes in the real world. —Maurice M. Kelso [2]

This quotation succinctly captures two major limitations that the agricultural economist faces in judging the worth of his research: (1) the acceptance of the conditionally normative (static) assumptions that attach to most of his work; (2) the value of his work as a "predictor of real world outcomes." In Kelso's article, and particularly in the above excerpt, these two points are intertwined, as perhaps they should be. They are related—one being cause; the other, effect. Kelso prefaced his critique by reciting some advances being made in agricultural economics, probably to avoid being put down as a hostile critic. Perhaps the same purpose is served by simply saying that where criticisms apply to agricultural economists they are equally applicable to professionals in economics generally and in the other social sciences.

The major challenge facing the social sciences is to expand our body of knowledge about how men will live together during future decades, given continued technological advance (or change) and enforced social change growing out of the greater quantum of human interaction necessitated by increased population and wealth. In his presidential address to the American Economics Association, Boulding [1] tended to excuse economics for not having a dimension of benevolence on the grounds that neither did it explicitly recognize malevolence. If economics is to continue to make a major impact on American social policy, it may have to recognize and accommodate in its projections the fact that benevolence and malevolence are significant policy variables.

Much of the past obsession of agricultural economics has been with criteria of material efficiency, assuming this was among the chief motivations that dictated normal human behavior. Yet over the past decade one of the more important influences on what social scientists have done or strived to do has been the emergence of social concern—concern for the well-being of the poor, racial minorities, educational opportunities, and the role of war in the exercise of national policy. Another new variable for the seventies will further complicate our normative assumptions—concern over the quality of environment. While some construe this simply as "Thou shalt not throw trash," it is becoming an extremely complex issue; already, traditional property rights are being challenged. Efficiency in production will remain a concern; but it will be a concern framed within environmental constraints.

The major subject of agricultural economics research has been the technical process. We have researched the farm, the input industries, and the processing, distribution, and retail system largely from the standpoint of measuring performance (which generally reduces to looking at efficiency) or comparing alternative technologies that might be applied. Excursions outside this mold, which have taken on some humanistic dimensions, have been largely descriptive, such as our concerns over distribution of income between the farm and nonfarm sectors or distribution of income within agriculture. But after describing areas of appropriate concern over human well-being, we typically revert and search for remedies in alternate mixes of known technologies.

This should not necessarily be construed as criticism. It would be hard to say that this type of orientation for agricultural economics, up to nearly now, was out of step with society. But in the words of a contemporary songwriter, "The times they are a'changin'." We must ponder the more difficult question of trying to achieve adequate analysis and prediction of that "real-worldness" described by Kelso, but again it is easier to see the need than to

show the way. Whether anyone can do that comprehensively is a matter of question. However, one can note changes that seem to be upon us and that should condition the training of agricultural economists if their product is to continue to have worth and therefore be in demand. Following are three such conditions:

1. The role of technology in our society will have to change from its orientation of "produce more, more efficiently" and "hang the secondary costs." We cannot much longer continue to overtax our country's and the world's capacity to tolerate environmental abuse.

2. Our construct of technology (heretofore emphasizing the role of capital goods) must broaden and mature. Technology's real contribution springs not from things but from ideas. It can be stated categorically that our phenomenal technological growth since World War II resulted almost entirely from our investments in education and the experimentation this permitted. Yet we have established few tangible measures upon which to evaluate or predict in the human resource capital dimension. Those measures we have are not necessarily the sufficient positive, predictive factors we would like to see, either in terms of productivity or resource durability. There are aspects of intellectual pursuits that are known to create greater strain on human beings and that, in contrast to physical labor, restrict active outlets for these strains. I refer to a recent projection of use of mild psychotropic medications by close to 90 percent of the population of this country within the next 15 to 20 years, rises in alcoholism, and growth in individual alienation, all of which are seemingly traceable to the increased institutionalization of the work lives of people—our most productive resource.

3. Psychic and esthetic goals must attain more prominence as compared with material goals, given the likelihood of greater instability in modes of human behavior, hence in predictability, growing out of increasing societal pressure. We have as yet seen only token manifestation of this phenomenon in current student unrest, civil rights demonstrations, and other isolated polarization of groups. Though many of these can be dismissed as atypical, we have the warnings of the Eisenhower Commission, the Kerner Commission, and others that these phenomena have real roots. There are tough questions before us: "What will be the esthetic we shall seek to optimize in another generation?" "What will be the process of institutional change?" (Is the old crisis-and-response approach the only one that will work, or can we come up with anticipatory designs and plans of action that will work?)

It is hard to offer a comprehensive set of ideas about the future orientation of agricultural economics research. What follows is at best a partial list of propositions that can be the subject of further dialogue.

1. In facing emerging research questions, is agricultural economics a well-defined, discrete discipline or is it but a subpart of social or behavioral science, not fully integrated but with a common theory of inquiry and certain unique analytical methods? Will the economist (by current definition) be able to cope with broader problems encompassing goals simultaneously related to such factors as institutional change mechanisms, psychic or esthetic factors, the biological and physical parameters of environmental concern, in addition or as partial alternatives to traditional value measures? Stated somewhat differently: Will the products of economic research, as an isolate, relate to the outputs of other disciplines, as will be increasingly required in future policy decision-making?

2. Do our present methods of training and predominant institutional forms for doing research permit attack on systems, rather than just on components of problems in a real-world sense? Problems most pressing for solution are increasingly of a highly aggregated nature; yet a high proportion of our inquiry is at the micro level. Beyond this, we seem to lack the theoretical links to build to the aggregate level or, in many instances, the wisdom in initial problem conception at the micro level to include all variables essential to aggregation of the whole. Our macro shortcomings seem to trace back to training so much oriented to the individual's professional progression that it encourages the undertaking of manageable, micro problems which can be wrapped up, published, and listed as credits toward promotion.

3. Have we put so much emphasis in our curricula on proficiency and precision in techniques that it constricts the subject matter, narrowing the capacity of students for conceptualization in research? Further, through such emphasis, have we created delusions about the attainable precision in economics? With the increasing number of externalities that seem to relate to almost any analytical model we undertake, can there be any great probability of precision in many of the things that economists research? The question might further be raised as to whether we have learned to use the computer in the area of its greatest potential. As we entrap it with ever-expanding models, requiring precision coefficients, do we not reduce it to an accounting machine, expecting it to produce a single deterministic result which some abberation of human behavior can render incorrect? There would appear to be an underused role for the computer as a rapid means of concept development, dealing less with precision and more with the testing of consistency of relevant models or theories dealing with problems of very large scope.

4. Have we created and warped our priorities between "basic" and "applied" research? We should perhaps first question whether any such valid distinction can be drawn. The terms nevertheless remain in vogue, with basic research seeming to at-

tach respectability, and applied research having less prestige. But realistically, is one not the product of the other? Which is which? And are both not of equal import to the individual as a professional economist and to society in terms of using the products of economic research? It seems obvious that the best of our most basic researchers get their most relevant hypotheses from excursions into the application of research results or experience in doing short-run applied research. Also, given the increasing complexity of problems to which we address ourselves and the corresponding complexity of the results of this work, it seems that only those who have the most fundamental knowledge of research can make appropriate and valid application. Thus the question: How can such a distinction be drawn, and why does it persist?

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NEEDED REDIRECTIONS IN ECONOMICS: COMMENT

Professor Dorner [2] has raised vitally important issues about the future of agricultural economics, and its practitioners. I could not agree more with his plea for redirected emphasis. My comments are directed not at specific points in the paper but at what I see as an underlying focus for his remarks, questions about the appropriate role of economics as a social science and economists as participants in the formulation of public policy.

Dorner seems to address himself to two distinct yet overlapping issues in the relationship between economic theory and economic policy. Both relate to a growing confrontation between the theory as traditionally defined and so-called relevant policy problems. He is concerned both with the ex ante question, "Should I or shouldn't I address myself to these problems as an economist and social scientist?" and the ex post question, "Are the policy recommendations suggested by economic theory any good?" While the specifics of his paper relate to the latter issue, that is, the application of familiar economic techniques to current development issues (domestic and international), he implies at least strong misgivings about economics as a discipline in dealing with these issues. I would not suggest that he hesitates to tackle the "new" issues—his record proves otherwise—but he does seem to worry about compromising the integrity of his discipline when he does so.

It pleases me and yet concerns me to hear an economist of Dorner's stature and experience confess to an identity crisis. I assumed such misgivings were exclusively for graduate students and untenured assistant professors. Apparently all of us confront the shattering question "So what?"—some more frequently than others. Some are looking ahead to a career in economics and wondering whether it's worth it; others are looking back to see whether there has been anything to be proud of. We would prefer not to have to choose between our discipline and our self-respect.

First, it seems to me that whether economists should get involved is largely a moot question. Economists are getting involved in the redirections that Dorner has outlined. I would agree with Mishan's advice that unless we do it someone else will, and we all know our judgment is better than most [5]. I would argue further that economists have been formulating economic policy for years. They may confess only to dispassionate advising on the implications of alternative courses of action, based on rigorous analysis, but their impact on selection and their inescapable association with political objectives often makes them practitioners. We somehow lived with this role in the past, so why worry about it with the new issues? Our only way out of this identity problem, it seems to me, is to rationalize doing what we cannot avoid. Constant rationalization is not trivial, as some might suggest; it is the only process that keeps economics, or economists, alive.

There are at least two strategies economists use to maintain their self-respect in the face of these so-called relevant issues. First, the economist may devote his energies to applying the tried and proven analytical and conceptual economic tools to new problems. This approach generally begins with the observation that the ceteris paribus conditions of traditional economic analysis either ignore or may even create the new problems. Income distribution, external benefits and costs, and resource mobility are assumed out of the picture or at best mentioned in a footnote. To retain his relevance and that of his discipline, the argument continues, the economist must direct his analytical machinery toward these "side issues." Paradoxically, however, the proponent of this strategy first argues that economics as we know it is hopelessly linked to our peculiar market system and thus incapable of being geared to problems that result from that system; and in the next step he constrains himself to these same traditional analytical devices in attacking the new problems.

For example, he may observe a discrepancy be-

tween private and social costs in the allocation of water resources of a river basin and then will spend the rest of his life working on a mathematical model for maximizing social return in the basin. If he had read his own introduction, he would realize that such a goal is close to hopeless; he is doomed to a life of frustration and error messages. By the same token, the economist who limits himself to those parts of the new issues capable of rigorous quantitative economic analysis is a "cop-out"; he is doomed to a permanent place in the appendix of huge multidisciplinary studies. In my opinion, the "new" economist who gets pushed around by his discipline is as myopic as the old-timer.

I wouldn't argue that economics is *the* social science and can solve all problems. I am saying that *no* discipline can solve them. These policy issues don't break down neatly into political issues and economic issues and sociological issues, each of which can be attacked by a separate discipline and later glued back together for a workable solution. The problems listed by Dorner basically involve interaction among individuals and groups trying to achieve divergent goals. Each social science contributes insights into the nature of these interactions. Solutions will come from reasonable men and women who have a primary concern with the problem itself and can put insights of several social sciences to good use.

It seems to me that we often take our economics far too literally and perhaps too seriously. We worry about the fact that a production function for good health or some other social good is less clearly defined than a production function for corn; yet we expect our science to produce single-value answers with the same precision as we prescribe the level of nitrogen. In many instances we expect far more from a series of analytical abstractions than they were ever meant to deliver. Thus the strategy of rationalizing our interests merely by directing our myopia at these different issues can lead only to frustration.

To some extent, Professor Dorner may have fallen into this trap. His uneasiness about tackling the issues of environmental quality, poverty, race relations, rural development, etc., *as an economist* are based on a very strict definition of economic theory: theory of the firm, markets, pricing, and equilibrium. He's concerned that economics as defined cannot produce better answers than those resulting from political compromise, personal preferences, or the dictates of dogma, as he has put it. I submit that there is little that is more dictatorial or dogmatic than economic theory taken too literally. The dichotomy in his paper between economics and the process of political compromise is indistinct and perhaps nonexistent.

Now let me expose some of my prejudices about the nature of economics, in the context of Dorner's comments. We seem to arrive at similar conclusions from slightly different directions. First, I think we should see economics as process, not procedure. James Buchanan has noted, "The role of the economist at base must be that of trying to understand a certain type of human behavior . . . A general solution, if there is one, emerges as a result of a network of exchanges, bargains, trades, agreements, contracts . . . The motivation of individuals to bargain is surely that of 'efficiency' defined in the personal sense of moving from a less preferred to a more preferred position" [1]. That makes sense.

The best way out of our identity dilemma, it seems to me, is to look past the strict formalized sets of abstractions that have worked so well for some issues and concentrate instead on the insights into human behavior that economics provides. An ecologist friend of mine says there are two great evils in this world—engineers and economists. In his next breath, though, he talks about achieving "acceptable" levels of water pollution and establishing a level of water quality beyond which the additional quality is not worth the extra cost. Now *that* is economics if I ever heard it. He has confused economics the discipline with a manifestation of some economic principles in the "growth mania," as he calls it.

Secondly, we should see economics as a system primarily for organizing information about the interactions among people and groups in a situation of limited resources and unlimited demands. The market is an institution devised to help in this allocation process, but it is only a manifestation of economics and not economics itself. Whether in the market or in the process of political bargaining, we can assume, for example, that an individual or group will get as much good as it can for a given cost. Good in this sense may be peace and quiet, or job stability, or influence; cost may be time, money, or effort. We can also predict that the individual will expend as little effort as possible to get a given level of good. If he can get it free, he'll take it. Further, our greedy individual will not expend another unit of effort if he has little likelihood of getting more good than effort. He won't waste any energy if he expects nothing back from it. Economists have built an impressive body of theory and analytics from these basic human propensities. If the notions of good and cost could be defined consistently and measured in some unit, we could probably develop a social welfare calculus that would produce social efficiency as we have with production efficiency. Abba Lerner talks about such a system in his *Economics of Control* [4].

I would argue that if we accept economics in its broad sense, as "a filing system for organizing empirical material and facilitating our understanding of it" (Friedman [3]), we can maintain our self-respect as social scientists and might even make useful contributions to solving the new problems. Our hesitancy can lead only to ulcers, while the real, challenging, exciting issues go marching by to some other social scientist with fewer professional scruples. We should tackle the problems of poverty, racism, and environmental quality with the confidence that our

judgment is better than most, partly because we have a body of theory that helps us understand both how these problems arise and how they might be solved.

For example, our observation of human economic behavior and our knowledge of the way that behavior is institutionalized in an industrial economy helps us to understand the roots of the environmental quality crisis. I doubt that a group of corporation leaders is consciously conspiring to mess up our environment. I also doubt that the drive for efficiency, in Buchanan's sense, is limited to old-line economists and engineers. Human nature is basically greedy. Even the ecologist will garner as much personal good as he can for a given amount of effort. Seclusion may be his good, or public notoriety, or an even higher university salary. Further, the physical characteristics of poor environment evolve at least partly from an inadequate set of institutions to harness individual and collective greed. Solution to the environmental problem will come, I submit, not by appeals to moral righteousness or by bottle pickups but through institutions that require those who pollute to bear a cost.

The free-rider argument is familiar to all welfare theorists and helps us to predict the success of alternative institutions for dealing with environmental issues. The individual will not incur personal costs by paying more for unleaded gas or returnable bottles when he sees little evident return from his actions. By the same token, we can't expect the paper manufacturer to incur dollar cost if he can continue to produce paper without it. But we can anticipate some effort if it will improve his net position—a better public image, or lower court costs, or lower production costs. This may seem obvious, but the rhetoric of the environmental movement suggests otherwise. Economics *might* tell us exactly the institution and the price needed to achieve X level of water quality, but that degree of precision is tough to achieve and perhaps unnecessary. More than that, an economist can suggest the *strategy* that can improve our environment.

Similarly, economics can help us to understand the dimensions, causes, and cures of poverty. Migration is largely an economic phenomenon whereby an individual attempts to improve his return to effort. Patterns of land use are profoundly economic—responses to income-earning potential. Income distribution is an economic variable and certainly helps to describe poverty. M.I.T. economist Lester Thurow pointed out in a recent seminar that training an unemployed person wil. ,iake him employed. Only when the employer is .ort of help and pressed for output will he adjust his standards sufficiently to bring in the unemployed. Until he experiences a cost by failing to employ these people, he can generate all sorts of moral, legal, and intuitively sound arguments for maintaining high educational and skill standards for his workers. Those in dollar or political poverty may face similar constraints in trying to influence public decisions. Until the rational decision-maker faces the likelihood of political costs, he will not think seriously of seeking out public preferences. Economic behavior at this level is so obvious and so dependable that we often look right past it.

My only point in all of this has been to suggest that economics does contribute to an understanding of the new issues. An economist has no corner on truth, but neither should he avoid these issues because they are difficult or political or imprecise. Poor policy recommendations or inaccurate perception of problems is not the fault of economics but of those who use it. If we as economists fail to tackle the problems enumerated by Dorner, it is because of our own short-sightedness, not inherent weaknesses of our discipline. Our answers will not be precise. No body of formal theory can accurately weigh the preferences of individuals and groups and permanently resolve conflicts.

But neither should we accept the idea that human interactions are random. Without some pattern to the relationships among individuals and groups there can be no social science. I strongly endorse Dorner's contention that it is the problems that don't fit the formal structure of economics that encourage us to revise the theory. An improved set of abstractions *must* be an important goal of research. With many of these issues we are at the stage of describing and diagnosing, as Dorner pointed out. For example, once we understand better the dimensions of the overwhelming problem of financing local public services perhaps we can develop information and institutions to improve the situation. Maybe we will revise our system of economic logic to reflect this understanding. Finally, maybe we can formalize all of this in a model that will tell a community how to establish reasonable trade-offs among community service alternatives. That's how theory is formulated; even Lord Keynes himself didn't do it overnight.

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ECONOMIC AND POLICY IMPLICATIONS OF POLLUTION FROM AGRICULTURAL CHEMICALS

Pollution from agricultural chemicals has resulted in restrictions on the use of some pesticides. There is increased pressure for more comprehensive regulations, and it is reasonable to expect further withdrawals and tighter restrictions. Depending on the authority used and the assumptions made the necessary action ranges from minor regulations, which would result in modest cost increases, to drastic withdrawals which would bring very high food costs accompanied by poorer quality. The matter is complex and controversial, and different decisions will produce different impacts.

We shall attempt here to interpret and predict some of the impact of restrictions and to suggest an approach to reducing pollution. These points are developed: (1) Farm programs based on acreage allotments have aggravated the pollution problem; a different approach to supply control is needed to reduce the incentive to substitute chemicals for land. (2) Producers in the South, especially cotton producers, will be most affected by restrictions. (3) Expected restrictions of agricultural chemicals in the 1970's will result in higher costs to producers; because export crops are primarily affected, the market system will not pass these costs on to consumers.

Apparently the agricultural chemicals most likely to be candidates for the tightest restrictions are the organochlorines [5, p. 1183].[1] These include DDT and the "aldrin-toxaphene" group which have a persistent residue problem and have been the leading insecticides used on cotton, corn, peanuts, and tobacco. These crops accounted for 87 percent of the organochorines used on crops in 1966 [7, p. 1]. A Commission report to the Secretary of Health, Education and Welfare in December 1969 recommended that the government "eliminate within two years all uses of DDT and DDD in the United States excepting those uses essential to the preservation of human health or welfare and approved unanimously by the Secretaries of Health, Education and Welfare, Agriculture, and Interior" [8, p. 8].

Insecticides and herbicides present the most pressing problem, but the runoff of fertilizers into streams and underground water are also causes for concern. Since cotton is the heaviest user of organochlorines it is clearly the crop most vulnerable to restrictions. Increased production costs, westward movement of production, and a smaller share of world production are trends that will continue in U. S. cotton.

Supply Control and Pollution

Application of high levels of chemicals is basic to the rapid increases in yield per acre achieved in the last two decades. The national farm programs based on relatively high price supports and tight acreage control have provided part of the incentive for heavy and perhaps excessive use of chemicals. Economists have long argued that the acreage control approach to limiting surpluses resulted in a malallocation of resources. The Food and Fiber Commission repeated it in 1967 [4, p. 21]. Now we can add the pollution problem to this argument. If it ever did, it no longer makes sense to pay farmers to withdraw land from use; then in turn to provide a price support that gives strong incentive to apply heavy amounts of fertilizers and pesticides to produce maximum yields on the remaining restricted acres. In many farm operations chemicals become a substitute for land because of the economic incentive from federal farm programs. In addition to the usual economic incentive to substitute variable inputs (chemicals) for a fixed input (acreage allotment), the procedure for determining the projected yield for supported crops rewarded producers who, by producing ever higher yields per acre, increased their future base allotment [2, p. 6].

Currently, approximately 55 million acres of cropland are diverted under various government programs; Tweeten estimated agriculture had over 6 percent excess capacity in 1967–1968 [6, p. 8]. Excessive applications of chemicals are suspected of being a part of the materials that turn up in the run-off into lakes, streams, and underground water supplies. A basic change in farm policy from acreage control to market quotas could either reduce the incentive or slow the rate of increases in the level of application. Supply control and price supports can be accommodated with either system.

Economic theory postulates that inputs will be used to the point where the marginal contribution equals the cost of obtaining another unit of the input. Furthermore, the economic rationale relating to substitution of chemicals for fixed land inputs is fairly well documented in the case of fertilizer. It is less clear for insecticides and herbicides. We found few studies directly concerned with this question (for example, see [3]).

To apply a few applications of pesticides to save all or a portion of a crop is not the question. It has been claimed by Edwards et al. that economic equilibrium of insecticide usage is being approached in certain areas, from the producer's short-run view. Their data suggest, however, that in the Southeast and South Plains it has been exceeded [1, p. 729]. We suggest that a market quota with a two-price system would reduce the incentive to apply "insurance applications" that sometimes exceed the economic optimum.

Restrictions and Profits

Withdrawal of certain chemicals from use will most likely result in substitutes that will be either

[1] More detail available in [2].

less effective (causing decrease in yields) or more expensive; thus higher per unit production costs are certain. In some cases these higher costs can be passed on to consumers; with farm products that depend partially on export markets, however, little of the costs can be passed on because in foreign sales the industry faces a fairly elastic demand. Therefore, in the case of feed grains, cotton, tobacco, wheat, and rice, farmers would have to absorb most of the extra cost, at least in the short run, unless the government chose to raise the support price or the income subsidy.

For farm products produced primarily for the domestic market the price and income effects would be of two types. For some products per acre yield would drop but supplies would remain nearly constant due to expanded acreage. In this case it is not likely all costs could be passed on in the short run. For other products total supply would actually decline as a result of withdrawal of chemicals. Demand being in most cases highly inelastic, the increased total revenue would likely exceed increased cost. The latter result would probably apply to some specialty crops, and some producers in the Pacific states could actually be making higher net revenues because suitable areas of production are limited.

Conclu

The concept of market quota now has more justification than ever before. If producers were given a limit on the amount of a product they could sell rather than a limit on how many acres they could plant, it would tend to reduce the incentive to obtain maximum output per acre. The objective would become that of minimizing cost for a given level of output.

Economists have argued before for market quotas on the basis of more efficient resource use. Not many people get excited about such an abstract concept, but they do get excited and enraged upon seeing dead fish, upon being told that certain wild life is threatened with possible extinction, and upon learning that their fatty tissues contain DDT. Such excitement and anger has brought about policy changes.

It seems clear to us that one of the first (and most practical) moves in the effort to reduce pollution would be to bring about a fundamental change in the operation of our current farm programs which would remove some of the incentive to cause pollution.

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A LINEAR ALTERNATIVE TO QUADRATIC AND SEMIVARIANCE PROGRAMMING FOR FARM PLANNING UNDER UNCERTAINTY: COMMENT

Hazell [4] has recommended the Minimization of Total Absolute Deviations (MOTAD) model as a linear alternative to the quadratic programming model for farm planning under uncertainty. More specifically, he has proposed the total absolute income deviation from the sample mean as a substitute for the sample variance in deriving efficient E-V farm plans. The MOTAD formulation is to be preferred, however, only in terms of computational efficiency in developing efficient farm plans, and one must be prepared for some loss in reliability of the efficient E-A results.

Hazell examined the statistical properties of his formulation and found that when the population of possible total gross margins is approximately normally distributed the relative asymptotic efficiency of the sample mean absolute deviation is 88 percent. For a population distributed in any other way the

statistical properties of the MOTAD model are unknown; its relative efficiency is therefore likely to be less than 88 percent. In order to conclude that the MOTAD model may have considerable advantages as an alternative to quadratic programming, regardless of the properties of the populations from which his sample data is drawn, Hazell has erroneously applied the Central Limit Theorem to the distribution of total farm gross margins.

The two different objectives of this note are (1) to point out the erroneous application of the Central Limit Theorem in Hazell's article; (2) to discuss the measurement of yield variability from trend, instead of from a sample average, and its implications for the MOTAD model.

According to Hazell, "... the Central Limit Theorem is applicable when sufficient numbers of activities enter farm plans and the activity gross margins are *independent over time*" [4, p. 55], and "most farm situations that justify sophisticated programming techniques are likely to involve a sufficient number of activities so that approximate normality holds by the Central Limit Theorem" [4, p. 59].

The Central Limit Theorem for the sum of random variables states that "the sum of a large number of *independent* random variables having any single distribution whatever (as long as it has a finite variance) is approximately normally distributed" [1, p. 143]. Note particularly the necessity that the terms in the sum be independently distributed.

Although there are circumstances under which the assumption of independence of the terms can be relaxed, the sequence of random variables can *only* be m-dependent [3, p. 215]. More specifically, a sequence of random variables $X_1, X_2, \cdots$ is m-dependent if $(X_1 \cdots, X_r)$ is always independent of $(X_s, X_{s+1}, \cdots)$, provided $s-r>m$. Therefore, if m or more consecutive X's are removed, the two remaining portions of the sequence are *independent*.

The Central Limit Theorem is applicable therefore only when a sufficient number of activities are included *and* the individual gross margins are *contemporaneously uncorrelated*. It is not necessary that they be independent over time. In the typical farm situation it is obvious that the contemporaneous farm activity gross margins must be strongly correlated with each other because of the common market forces and weather conditions to which they are subject, and thus the Central Limit Theorem is not applicable in this situation.

Because the Central Limit Theorem is not applicable, the distribution of total gross margins is normal *if and only if* the individual gross margins are normally distributed (no matter whether the individual terms are independent or not). Thus, the statistical properties and the corresponding relative efficiency of the MOTAD formulation for farm planning under uncertainty must necessarily be the subject of further questioning and research.

The second objective of this note is now considered. Swanson [5] has observed that during the 1927–1953 period there has been an upward trend in county yields for the five major crops studied—corn, soybeans, oats, wheat, and hay. Technical advance is responsible for this upward yield trend.

Since a trend can be estimated by regression analysis and projected into the future, the change in a variable resulting from trend cannot be considered unexpected, as is the case with random variation. Thus, historical gross margin records must be adjusted for trend in determining their sample variance. The relevant variance is derived from the year-to-year deviations from trend. This is especially relevant when we are making a long-term farm plan based on past experiences.

In terms of Hazell's notation, if

$$y_h^+ = \left| \sum_{j=1}^{n} (C_{hj} - g_j)x_j \right|$$

when

$$\sum_{j=1}^{n} (C_{hj} - g_j)x_j$$

is positive and zero otherwise, then $\sum_{h=1}^{s} y_h^+$ is the sum of the absolute values of the positive total gross margin deviations around the trend line. Similarly, let $\sum_{h=1}^{s} y_h^-$ be the sum of the absolute values of the negative total gross margin deviations around the trend. Unfortunately, since the g_j, $(j=1, \cdots, n)$, are no longer sample mean gross margins,

$$\sum_{h=1}^{s} y_h^+ \neq \sum_{h=1}^{s} y_h^-,$$

and thus Hazell's simplified model with the objective of minimizing $\sum_{h=1}^{s} y_h^-$ will not lead to a solution identical with that obtained with his original model which minimizes

$$\sum_{h=1}^{s} (y_h^+ + y_h^-).$$

This point is by no means new and Hazell himself has implicitly indicated this in his article. However, it is worthwhile to point out that even for farm planning under uncertainty we would normally prefer to estimate a trend to allow for technological change rather than to use a sample average when projecting future mean gross margins. Consequently, the simplified MOTAD model is not applicable.

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A LINEAR ALTERNATIVE TO QUADRATIC AND SEMIVARIANCE PROGRAMMING FOR FARM PLANNING UNDER UNCERTAINTY: REPLY

Chen is clearly correct in criticizing my appeal to the Central Limit Theorem in attempting to justify the MOTAD model as a substitute for quadratic programming in deriving efficient E-V farm plans. The applicability of the Central Limit Theorem can be argued only on the basis of numbers of activities in the final solutions if a sufficient number of the activities have contemporaneously uncorrelated gross margins. However, this does not imply that all gross margins must be contemporaneously uncorrelated, for with complex farm businesses there might be enough activities to ensure approximate normality when only a subset are uncorrelated. Presumably this is what Hirshleifer [2, pp. 522] had in mind when referring to "well-diversified" portfolois in making a similar appeal to the Central Limit Theorem for the distribution of total returns from complex portfolios.

Unfortunately, contemporaneous uncorrelatedness among many activity gross margins is not likely to occur very frequently in farm planning problems, so that Chen rightly says that normality in total gross margins will only occur given that individual activity gross margins are normally distributed. To assume this a priori might seem unduly heroic, but an alterative appeal to the Central Limit Theorem is at hand. The gross margin of an activity is defined as gross output (price times yield) less all variable or direct costs. Obviously, under conditions of uncertainty the gross margin is a sum of random variables and, given sufficient contemporaneously uncorrelated components, will be approximately normally distributed. Again this is not as general or appealing as my initial and erroneous application of the Central Limit Theorem and does leave some loose ends in a discussion of the relative efficiency of the MOTAD model as a substitute for quadratic programming in deriving efficient E-V farm plans. However, for all practical purposes I still think there are good grounds for optimism about the potential value of the MOTAD model in this respect.

First, if sufficient empirical evidence were available to suggest that the distribution of total gross margins for a farm plan were actually asymmetric, then an E-Semivariance criterion would be more appropriate than an E-V criterion, so that the properties of the MOTAD model as a substitute for quadratic programming do not arise. The only remaining problem then is to discover the reliability of the MOTAD model for symmetric but nonnormal distributions. Tukey [3] has reported some useful work which has a direct bearing here. He has shown that for symmetric but wider distributions than the normal,[1] the relative asymptotic efficiency of the sample mean absolute deviation improves above 88 percent and can actually exceed 100 percent. Chen is apparently incorrect in claiming that the relative efficiency must fall. In his conclusions Tukey is downright critical of the value of the sample variance for even large samples when given only imperceptible nonnormalities and suggests that the mean absolute deviation may be very useful for both large and small samples.

Second, it should be remembered that arguments about the reliability of the MOTAD model based on the relative efficiency of the sample mean absolute deviation and sample standard deviation totally ignore the fact that the farm constraints tend to force similar solutions in terms of the farm plans obtained. For some types of farms the constraints can compensate for a considerable degree of inefficiency in the variance estimator, and I suspect that is why I have obtained almost identical farm plans from the MOTAD and quadratic programming models for intensive fresh market vegetable farms in New York and Florida.

On a more general level, I regard the E-A criterion as having considerable validity in its own right as a decision criterion, and my primary intention in proposing the MOTAD model was to offer a more convenient alternative to the E-V criterion and quadratic programming model. The fact that in practice the two models have been observed to lead to very similar farm plans emerges as an interesting and extremely useful feature of the MOTAD model and suggests a convenient computational substitute for quadratic programming for those who still prefer an E-V approach.

Chen also raises the problem of trend in time series data and argues that the simplified MOTAD formulation is not applicable when gross margin deviations are measured around trend rather than sample means. This problem is easily avoided, however, by removing trend prior to estimation of the sample

[1] Strictly his results hold for distributions that are derivable by contaminating a normal distribution with observations from another and wider normal distribution. Such distributions will retain a general bell shape but are probably general enough to approximate most symmetric distributions observed empirically.

mean gross margins g_j around which gross margin deviations are measured. For example, suppose we postulate a linear trend such that the gross margin of the jth activity in the hth year can be written as

$$c_{hj} = \alpha_j + \beta_j h + \epsilon_{hj}$$

where ϵ_{hj} is an error term with $E(\epsilon_j) = 0$.

Such an equation can be fitted by regression techniques as Chen suggests,[2] to obtain the estimates a_j and b_j of α_j and β_j respectively. Trend can then be removed from c_{hj} by subtracting $a_j + b_j h$ to give

$$\bar{c}_{hj} = e_{hj}$$

where e_{hj} is a residual of regression.

Using these data, the sample mean gross margin of the jth activity is

$$g_j = \frac{1}{s} \sum_{h=1}^{s} \bar{c}_{hj} = 0$$

because $\sum_{h=1}^{s} e_{hj} = 0$. It follows that

$$\left| \sum_{j=1}^{n} (\bar{c}_{hj} - g_j) x_j \right| = \left| \sum_{j=1}^{n} e_{hj} x_j \right|$$

[2] Note that statistical inference about the estimated parameters is practically possible only if we assume the residual to be normally distributed. This is of course equivalent to assuming that activity gross margins are normally distributed around their trend line!

and that the sum of absolute values of the positive total gross margin deviations (defined as $\sum_{h=1}^{s} y_h^+$ where $y_h^+ = |\sum_{j=1}^{n} e_{hj} x_j|$ when $\sum_{j=1}^{n} e_{hj} x_j$ is positive and zero otherwise) must be equal to the sum of absolute values of the negative total gross margin deviations (defined as $\sum_{h=1}^{s} y_h^-$ where $y_h^- = |\sum_{j=1}^{n} e_{hj} x_j|$ when $\sum_{j=1}^{n} e_{hj} x_j$ is negative and zero otherwise). Minimizing $\sum_{h=1}^{s} y_h^-$ will therefore lead to the same solution as minimizing $\sum_{h=1}^{s} (y_h^+ + y_h^-)$ in the MOTAD model, so that the simplified formulation is applicable.

When trend is removed in this way, the gross margin forecasts used in the expected income equation of the MOTAD model (that is, the f_j coefficients in my paper) must incorporate the trend component and will thus differ from the g_j coefficients. In effect the treatment is the same in principle as that for incorporating subjective estimates of the mean gross margins as indicated in my paper. Then only the f_j coefficient are adjusted and the g_j coefficients remain as sample means. These considerations are discussed more fully elsewhere [1, ch. 4], and are also applicable to the quadratic programming model.

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FLOW-OF-FUNDS SOCIAL ACCOUNTS FOR THE FARM SECTOR: COMMENT

It is encouraging to see the emphasis placed by Penson, Lins, and Irwin [5] on flow-of-funds accounts for the farm sector. Such flow-of-funds information has been noticeably deficient in both micro and macro farm accounting systems. Indeed several studies[1] that projected capital and credit needs in agriculture based on flow-of-funds were hampered by the absence of appropriate data. While income statements and balance sheets contribute information on the value of production over a period and the value of a business (or aggregate of businesses) at a given point in time, neither statement reveals information about financing activities, uses of farm income, capital investment expenditures, nonfarm income, and consumption and tax withdrawals. A flow-of-funds statement will provide these kinds of information, which are essential for an overall evaluation of the financial position of a sector of the economy.

Thus we support the general thrust of these authors' arguments regarding the usefulness of a flow-of-funds approach to farm accounting. However, we feel that further discussion is warranted regarding the structure of a flow-of-funds account and the nature of the funds involved. In this comment we propose to present (1) a discussion of several definitional and conceptional difficulties with the Penson, Lins, Irwin article, (2) an improved sources and uses of funds (SAUF) statement, and (3) some problems with flow-of-funds accounts.

The published article has several definitional difficulties. First is the obscure definition of the nature of funds. In the first footnote [5, p. 1] flows of funds are said to arise from financial transactions that are described in terms of balance sheet items rather than as cash flows items. This definition seems to imply that the purchase of real estate, for example, would

[1] For example, [2, 3, 4].

not be a financial transaction since real estate is an asset of one party but is not a liability of another. Our alternative definition describes a financial transaction as the exchange of one asset for another both valued in terms of dollars. The SAUF statement is then the summation of financial transactions in the sector for some accounting period.

A second definitional difficulty is found in the abstract of the article which states that SAUF statements ". . . relate changes in balance sheet accounts to income statements, describing movement from one balance sheet to the next." This is partially true of course, but more than flows of funds affect the balance sheet. Capital appreciation, depreciation, casualty losses, noncash gifts and inheritances, and internal growth, such as retention of home-produced calves in a herd, will affect the level and value of assets in the balance sheet; however, these do not represent flows of funds.

The article could have benefited from the development of a conceptual model of the SAUF statement exclusive of data considerations. In fact, the concern over data availability led to omission of several sources and uses of funds. The article included net farm income, nonfarm income, and net increases in debt as sources of funds. However, it failed to mention cash gifts and inheritances and sale of assets as sources of funds.[2] While the total inflows and outflows arising from asset sales between farmers would be equal, the incorporation of these flows in aggregate funds analysis would still be appropriate.

Similarly, some key uses of funds were overlooked. Farmers can also use funds for gifts and inheritances to nonfarmers and, more importantly, for real estate purchases including repurchases from nonfarm heirs or owners. Proprietor withdrawals were mentioned as a use of funds. This item could be disaggregated into federal income taxes, social security payments, and family consumption expenditures.

On the other hand, several items included in the SAUF statement have no basis for inclusion. To include appreciation in real estate as either a source or use of funds makes little sense. Appreciation is not a transaction and does not generate a flow of funds; it represents only an accounting revaluation of assets. When appreciated assets are sold or used as collateral in borrowing, the SAUF statement will record the appropriate flow of funds.

Capital consumption (depreciation) is listed as a source of funds, but it is only an accounting procedure for allocating the cost of a long-lived asset to the accounting periods comprising its useful life. In no way does depreciation provide funds. The real inflow of funds arises from total cash receipts and government payments.

Net change in farm inventories is treated as a use of funds. While inventory changes may represent capital accumulation or potential (unrealized) income, they are not financial transactions and do not involve flows of funds.

Table 1. Sources-and-uses-of-funds statement for the farm sector

Sources of funds
Farm marketing receipts and government payments
Nonfarm income
Reduction of financial assets
Sales of capital items
Real estate borrowing
Non-real estate borrowing
Cash inheritance and gifts
Total sources of funds
Uses of funds
Farm operating expenditures
Capital expenditures: land, buildings, durables, breeding livestock
Nonfarm business expenditures
Additions to financial assets
Proprietor withdrawals: consumption, income taxes, social security taxes
Real estate debt repayments
Non-real estate debt repayments
Cash inheritances and gifts
Total uses of funds

With these comments in mind we wish to suggest a flow-of-funds account that will more appropriately summarize the flows arising from all financial transactions in the farm sector. This flow-of-funds account should indicate the sources of funds for a sector of the economy during an accounting period and the amount of funds contributed from each source, as well as the uses of all funds during that period. Thus an ideal structure for a SAUF statement for the farm sector could appear as outlined in Table 1.

The reporting of gross flows overcomes the problems that Penson, Lins, and Irwin encountered in specifying net flows as either sources or uses of funds. In fact the net changes in flows imply a difference between inflows and outflows of funds. Thus in their article net farm income implies a source of funds from farm receipts and a use of funds for farm operating expenses. Net changes in real estate debt and non-real estate debt imply a source of funds from borrowing and a use of funds for debt repayment.

The authors pointed out that some of their definitions were conditioned by the availability of data with which to estimate flows. Data problems can be a readily admissible constraint and may require modifications in the flow analysis. However, the proper conceptual and mechanical specification of accounts with associated data requirements may stimulate the provision of appropriate data by statistical reporting services. We suggest that the sources and uses of funds information provided in Table 2 is more informative than the approach taken by Penson, Lins, and Irwin. Reasonable data seem to be available for estimating the most significant flows of

[2] Gifts and inheritances of cash are considered as a flow of funds to be included, although such flows are not transactions as defined earlier.

Table 2. Sources-and-uses-of-funds statement for farm sector, United States, 1967

		billion dollars
Sources of funds		
Cash receipts from farm marketing[a]		42.5
Government payments[a]		3.1
Nonfarm income[b]		10.7
Real estate debt extended[c]		5.1
Non-real estate debt extended[d]		17.5
Sales of real estate[e]		1.8
Total sources		80.7
Uses of funds		
Farm operating expenses[a]		28.9
Capital expenditures[b]		6.1
Net change in financial assets		1.0
Real estate purchases[f]		5.4
Real estate inheritances, foreclosures, and others[g]		0.9
Repayment of real estate debt[h]		2.9
Repayment of non-real estate debt[i]		15.0
Proprietor withdrawals:		20.5
Income tax[b]	1.7	
Insurance contributions[b]	0.3	
Family consumption and investment[j]	18.5	
Total uses		80.7

[a] From *Balance Sheet of the Farming Sector, 1969* [6, Table 19].
[b] From *Farm Income Situation* [7, Tables 5H, 17H, 19H].
[c] From *Agricultural Credit and Related Data, 1968* [1, Table 12].
[d] Estimate. PCA's loaned $5.4 billion and their outstandings increased by only $0.5 billion. Also consistent with published Canadian data. While the figure is only an estimate, it helps to focus on the need for more reliable data. The difference between extended and repaid is the same as published data.
[e] Estimated at one-third of voluntary sales. From *Farm Real Estate Market Developments* [8, p. 15].
[f] From *Farm Real Estate Market Developments* [8, p. 15].
[g] Estimated from Table 12 in *Farm Real Estate Market Developments* [8, p. 20].
[h] Estimated as difference between real estate debt extensions and change in outstandings as shown in *Balance Sheet of the Farming Sector, 1969* [6].
[i] Estimated as difference between non-real estate debt extensions and change in outstanding non-real estate debt as shown in *Balance Sheet of the Farming Sector, 1969* [6].
[j] Obtained by subtraction to make sources and uses equal.

funds in gross terms. The main exception is non-real estate debt extensions and repayments; only production credit associations report sufficient data to estimate these transactions.

While several features of our SAUF statement (Table 2) differ from the Penson, Lins, and Irwin analysis, the most noticeable difference is in the estimate of proprietor withdrawals. This estimate represents actual funds withdrawn from the sector for personal taxes, social insurance, and family expenditures. It does not reflect rental values of farm dwellings or home product consumption. Proprietor withdrawals of $20.5 billion are somewhat below the sum of net farm income and nonfarm income, indicating that in 1967 farmers did make net investments into the farm sector from net income. Conversely, Pension, Lins, and Irwin suggested that proprietor withdrawals were greater than the total of net farm income and nonfarm income.

Sources and uses of funds must be equal in any accounting period. Beyond the need for accuracy and completeness, no special significance need be attached to this equality. More interesting information arises from the analysis of the structure and relative importance of the various sources and uses of funds and implications for the financial position of the sector. Thus a SAUF statement is not expected to be a perfect link between an income statement and balance sheet; rather, it can stand alone as a measure of financial position.

Finally we would like to draw attention to some remaining conceptual and data problems associated with flow-of-funds accounting. While the focus has been on a farm sector including households, the definition of the sector is still not precise. For example, some of the flows data (especially real estate and some farm debt) include nonfarm landlords; while other data (nonfarm income and change in financial assets, for example) exclude nonfarm landlords. At this time the quality of available data does not permit separation of farm operators from nonfarm landlords. Also, even if the sector definition included only farm operators and their households, the entry of new farmers and exit of retiring farmers during the year introduces conceptual and practical problems that complicate flow-of-funds analysis.

Inheritances and gifts of noncash assets are capital flows that enter and leave the sector much as appreciation and casualty losses. While these represent neither flows of funds nor transactions, they are often easily convertible to funds and are of interest to one studying financial aspects of the sector.

The authors are to be commended for their attempt to bring flow-of-funds accounts before the profession. The purpose of this comment is to add further impetus in the direction of flow-of-funds accounts.

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FLOW-OF-FUNDS SOCIAL ACCOUNTS FOR THE FARM SECTOR: REPLY

Brake and Barry initially focus on our definition of flow of funds. Unfortunately they fail to recognize that our stated objective was to develop an account consistent with social accounting systems in general and existing farm sector social accounts in particular. They propose an alternative definition of financial transactions that violates existing flow-of-funds (FOF) social accounting convention.[1] FOF social accounts include not only financial transactions but nonfinancial transactions as well [6, p. 13]. Nonfinancial transactions can be identified by the fact that a change in a real asset appears on only one balance sheet, that of its owner.

Brake and Barry contend that capital appreciation has no basis for inclusion in a sector sources-and-uses-of-funds (SAUF) statement in the FOF social accounts. The justification for including capital gains and/or losses has been well documented in social accounting literature. Robinson [7, p. 262] suggests that "... estimation of capital gains and/or losses and assignment of them by sectors would produce greatly improved (FOF) accounts and would create the possibility for more meaningful economic analysis." Tobin [9, p. 191] points out that "stocks are altered also by capital gains and losses: FOF (accounts) cannot be properly interpreted without attention to the simultaneous changes in valuation of assets." Finally, Sigel [8, p. 79], in choosing between recording capital gains on a current basis or a realized basis, suggests: "Current capital gains, both on tangible and financial assets, however, would seem to be a more significant determinant of behavior with respect both to portfolio decisions and current expenditure and income decisions; transactors have, after all, some idea of the value of their property, even if they carry it at cost on their books. It would probably also be closer to balance sheet valuations that are most significant for economic analysis."[2] In a similar vein, Brake and Barry argue that capital consumption and net changes in inventories should not be considered in a SAUF statement. This conclusion is inconsistent with FOF social accounting convention as evidenced, for example, by the National FOF Matrix published by the FRB in the Federal Reserve Bulletin [1, p. 992]. Thus capital appreciation, capital consumption, and net changes in inventories represent noncash flows of capital internal to the sector and should be entered as nonfinancial transactions in the FOF social accounts. To exclude these flows, as Brake and Barry suggest, fails to distinguish between cash flow accounting and FOF social accounting. The latter are distinct from cash flow accounts since they include internal noncash flows of capital.

Another concern of Brake and Barry is our netting of the SAUF statement. To begin with, we did not encounter any unique problems in specifying net flows, as implied by Brake and Barry. Our "Potentials and Directions" discussion [4, p. 6] explains why the account was netted: We felt it desirable for users of the FRB farm business account to analyze our alternative proposal on a comparable basis.

Brake and Barry specifically mention two sources and uses that we "failed to mention," cash gifts and inheritances and cash purchases and sales of assets. A closer inspection shows that this is not the case. These transactions are included, but on a net basis. For example, the net change in holdings of money balances resulting from cash inheritances and gifts are aggregated with the net changes in other holdings of money balances, time deposits, etc., in "net change in financial assets" [4, Table 2, line 9]. In fact, they are measured on a net basis in an *identical* fashion in the Brake and Barry account (see their Table 2, line 10 above). Net investment in our SAUF statement [4, Table 2] represents purchases minus sales plus unrealized capital gains and improvements. Purchases minus sales *within* the farm sector cancel, leaving the change in stocks to be comprised of unrealized capital gains, capital improvements, and purchases from and sales to the nonfarm sector. In general, this is equivalent to taking the net change in stocks of assets reported at current market value in the *BSFS*.

In discussing their estimates of investment in the farm sector, Brake and Barry state: "Proprietor withdrawals of $20.5 billion are somewhat below the sum of net farm income and nonfarm income, indicating that in 1967 farmers did make net invest-

[1] The interested reader is referred to [2, 5, 6] for further exposition on the definitional structure of FOF social accounts.

[2] As Sigel suggests, a capital gain in a set of flow accounts can be considered a simple, separate "internal flow" involving a debit entry to the capital account, which records the revaluation of an asset, and a corresponding credit entry, which records the capital gain in the current account as a saving or a "current capital gain."

ments in the farm sector." Implicit in this statement is a definition that proprietor net investment in the farm sector is equal to net farm plus nonfarm income less proprietor withdrawals. Comparing this definition with our definition [4, equation (3.1)], we see two differences. First, we exclude "net changes in financial assets," while Brake and Barry do not, in determining the level of proprietor net investment *in the farm sector*. We would argue that an increase in holdings of financial assets primarily represents investment by farm proprietors in the *nonfarm sector* and should not be included in proprietor net investment in the *farm sector*. The second and more important difference comes in the treatment of noncash flows of capital. Our definition of proprietor net investment in the farm sector includes noncash flows of capital while Brake and Barry exclude them. Stated another way, our definition measures net investment on a current-market-value basis, while Brake and Barry propose measuring investment on a cost basis. The appropriate choice depends upon the objective or question one wishes to answer.

We believe that the approaches to aggregate flow analysis suggested by Brake and Barry and our original article are both useful when evaluated in a larger context; that neither is right or wrong per se. As we previously emphasized [4, p. 6], definitions and conventions are predicated on the usefulness of the accounts. Usefulness may be defined for a specific purpose or in a general way for a variety of purposes. Our objective was to meet a felt need for a SAUF statement consistent with existing social accounting convention and with data in the *Farm Income Situation* and the *Balance Sheet for the Farming Sector*.[3] Brake and Barry utilize a variety of data sources. Their objective was to construct a SAUF statement that includes gross cash flows but excludes noncash flows of capital. This too measures a felt need, that of measuring cash flows in the farm sector.

[3] This assumes that the *FIS* and the *BSFS* are internally consistent; that flows of expenditures, depreciation, etc., in the *FIS* are conceptually and definitionally consistent with the stocks of assets reported in the *BSFS*. If not, the discrepancy would be reflected in the SAUF statement.

The SAUF statement we presented in [4] includes both cash and internal noncash flows of capital on a net basis. Lins and Penson have elsewhere [3] proposed extensive grossing and disaggregation of the SAUF statement along geographic, demographic, and transactions lines. The real question before the profession therefore is not one of netting versus grossing of the account but rather whether it is appropriate to include internal noncash flows of capital to answer a given question. It seems largely arbitrary, in the absence of any specific purpose to provide context, to define flows of funds either as the equivalent of cash flows or on an accrual basis. Brake and Barry state, and rightly so, that a sector SAUF statement should provide information that is "essential for an overall evaluation of the financial position of a sector of the economy." We suggest, however, that this can best be done if both realized and unrealized forms of current saving and wealth are brought into the analysis.

Brake and Barry's contention that "a SAUF statement is not expected to be a perfect link between an income statement and a balance sheet" again reflects a monopurpose viewpoint that we consider unnecessarily limiting. Our own effort specifically *was* expected to provide such a link—an approach, we might add, that is consistent with much of the literature on the aggregate social accounts. We object to their attempt to limit the SAUF statement to serving a single master.

As they (and we) noted, sector entry and exit create difficult conceptual problems, and the solutions are almost always compromised by data availability. The plea for better data seems premature until we answer the question "better for what." A difficulty usually encountered is that the data are almost exclusively secondary, having been collected for other purposes. Once the important multiplicity of purposes in collecting data and the attendant needs are recognized, we are in a position to attack the data problem wherever one exists.

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RANDOM COEFFICIENT REGRESSION MODELS AND CARCASS PRICING: A COMMENT*

Ikerd and Cramer [2] have presented a method for pricing pork carcasses and hogs that involves the use of cross-section and time series data in a two-step procedure designed to estimate carcass value on the basis of sets of wholesale prices. In the first step the value per hundredweight of carcass i in time period t (Y_{it}) is linearly related to measures of relative backfat thickness (X_{i1}) and carcass weight (X_{i2}).[1] That is,

$$Y_{it} = A_{0t} + A_{1t}X_{i1} + A_{2t}X_{i2} + E_{it}$$

where A_{0t}, A_{1t}, A_{2t} are parameters that may differ between time periods $t=1, 2, \cdots, m$ and E_{it} is the error term with the usual properties. The values (Y_{it}) are then calculated for a set of $i=1, 2, \cdots, n$ carcasses, based upon wholesale prices of the various standard cuts at each of $t=1, 2, \cdots, m$ time periods. Next these m sets of n carcass values are regressed upon the previously noted variables to obtain m values for the parameters A_{0t}, A_{1t}, and A_{2t}.

Their second step involves the relation of the parameter values to four variables reflecting relative prices of carcass components (loins, hams, etc.). These variables are denoted Z_{1t}, Z_{2t}, Z_{3t}, and Z_{4t}. Values of the $\hat{A}_{jt}$, $j=0, 1, 2$, are related to the variables denoting relative prices by applying least squares to the equations.

$$\hat{A}_{jt} = B_{j0} + B_{j1}Z_{1t} + B_{j2}Z_{2t} + B_{j3}Z_{3t} + B_{j4}Z_{4t} + e_{jt}$$

for $j=0, 1, 2$.

With the equations so obtained it is argued that the value of pork carcasses can be estimated by

$$\hat{\hat{Y}}_{it} = \hat{\hat{A}}_{0t} + \hat{\hat{A}}_{1t}X_{i1} + \hat{\hat{A}}_{2t}X_{i2},$$

where the double hats denote the two-step estimators.

Our comments on the paper by Ikerd and Cramer are intended to provide a basis for reassessing the two-step estimating procedure. In particular, since the A_{jt} are regressed on relative prices in the second step it would appear to be more appropriate to specify them initially as random coefficients.[2] With such a specification and the availability of time series and cross-section data, the parameters (A_j) can be more efficiently estimated by utilizing a method recently presented by Swamy [3].[3] The method yields a consistent and an asymptotically efficient estimator of the means of the parameters (A_j) and an unbiased estimator of their variance—covariance matrix [3, pp. 316–317]. Thus the random coefficient model provides an estimation procedure that corresponds more closely to the initial carcass model specification while at the same time giving coefficient estimates that have desirable large sample properties.

To illustrate the Swamy random coefficient model as well as the consistency of the associated stochastic specifications with the carcass model, we have applied it to a set of data similar to those used by Ikerd and Cramer.[4] The data employed are based upon 240 carcasses and 44 sets of prices. In terms of our earlier notation, $m=44$ and $n=240$. The carcass model applied to this situation can be written in matrix terms as

$$Y_t = X_tA_t + E_t; \quad t = 1, 2, \cdots, 44,$$

where Y_t, E_t and X_t correspond to sets of observations on the cross-section and A_t is a parameter vector. The stochastic assumptions are that the A_t and E_t are independent; the A_t are only contemporaneously correlated and distributed $N(\bar{A}, \Delta)$; the E_t are only contemporaneously correlated and distributed $N(0, \sigma_{tt}I)$ (see [3, p. 312]).

Using these specifications which, as noted above, appear to conform to the intuitive justification of the model by Ikerd and Cramer, we can estimate the $\bar{A}_j$ and their asymptotic variance covariance matrix. Instead of reproducing the Ikerd-Cramer results

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* Data for the reestimation of the model were generously provided by John E. Ikerd and Charles L. Cramer.

[1] For a more precise definition of the variables see the original paper [2]. As our notation is identical, we have and will only nominally allude to the more precise definitions of the terms.

[2] In the second step of the procedure the A_{jt} are taken as random variables. Unless this randomness is attributed to the sampling errors (which does not appear to agree with the intuitive justification for the carcass pricing model) from the first step regressions, the A_{jt} must be taken as random variables in the initial equation.

[3] See also Hildreth and Houck [1]. The Swamy procedure is applied here because the time series and cross-section model conforms more directly to his specifications.

[4] The full set of data upon which the results in [2] were based were unavailable or would have been quite expensive to duplicate. The data used were readily available and are comparable to those of the initial study: a backfat range from 1.0 to 2.2 inches and a weight range from 135 to 191 pounds. The 44 sets of prices were for January, April, July, and October, 1955–1965. The original analysis included 70 sets of prices taken between August 1967 and January 1969.

with this estimation procedure we shall use it to provide information that was unavailable for the initial model, thus highlighting, it is hoped, the advantages of the random coefficient specification. First, because of the more precisely specified distributional assumptions, it is possible to derive a test for the hypothesis $A_1 = A_2 = \cdots = A_{44}$. This test is of importance in the carcass model because an inability to reject the hypothesis would cast considerable doubt on the advisability of proceeding to the second step of the estimation procedure. Applying the test proposed by Swamy [3, p. 319] resulted in a rejection of the hypothesis at the 1 percent level.[5]

Secondly, on the basis of the data employed, A_0, A_1, and A_2 were found to have means 28.74, -1.73, and $-.036$ respectively. The asymptotic variance-covariance matrix for these estimators is:

$$\begin{bmatrix} .3725621 & -.0117127 & -.0005310 \\ -.0117127 & .0010819 & -.0000141 \\ -.0005310 & -.0000141 & .0000018 \end{bmatrix}$$

with square roots of the diagonal elements, .61037, .03286, and .00134 respectively.[6]

The preliminary tests, facilitated by the availability of the means and sampling variances and covariances of the A_j, provide a much stronger foundation on which to base the second-step results. As the second-step procedures proposed by Ikerd and Cramer are appropriate for this revised specification of the model, they are not recalculated. The second-step regressions simply *condition* the "observed" random variables, $\hat{A}_{jt}$.

To conclude, we have suggested and applied an improved estimation procedure for the carcass value model. While the proposed procedure is somewhat more elegant from a statistical point of view, its major advantage for the carcass and similar types of models is the hypotheses testing that is permitted by the estimated variances and covariances. With such an approach Ikerd and Cramer could have added some information on statistical reliability to their already interesting results.

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[5] The F statistic is employed and is calculated on the basis of the ratio of the explained sum of squares for the restricted as compared to the unrestricted carcass model.

[6] Since the estimators of A_0, A_1, and A_2 are Aitkens estimators, it was necessary to obtain an estimate of Δ as an intermediate step in the procedure. In estimating Δ according to Swamy [3], we found negative but very small variances for Δ_{11} and Δ_{12}. These negative estimators for variances turn out to be not uncommon [1, p. 587; 3, p. 315; 4]. In such circumstances, biased but more efficient estimators can be obtained by setting the problem variances equal to zero [1, p. 587]. This method was tried in our case but resulted in estimates of the A_j that were numerically quite close to those presented.

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EFFECTS OF MISSPECIFICATIONS OF LOG-LINEAR FUNCTIONS WHEN SAMPLE VALUES ARE ZERO OR NEGATIVE: COMMENT

Johnson and Rausser [1] are concerned with a nonlinear regression equation of the form

$$(1) \qquad Y = \alpha_0 X_1^{\alpha_1} X_2^{\alpha_2} \cdots X_k^{\alpha_k} \exp(u),$$

which is commonly fitted to data by a logarithmic transformation yielding

$$(2) \quad \log Y = \log \alpha_0 + \alpha_1 \log X_1 + \cdots + \alpha_k \log X_k + u.$$

The problem analyzed is a situation where zero or negative values of the independent variables in the sample data leave the logarithmic transformation undefined for some data points (observation units). They argue that deletion of these observations gives up sample information and thus is a statistically inefficient procedure.

They show that addition of a constant to a variable across all sample points leads to bias with respect to the original model of (1); likewise, bias is shown to result if only the zero or negative points are converted to positive values by adding a constant. Then they aptly point out that the crux of the problem is the model itself, that is, equation (1) must be respecified to accommodate negative or zero values. Johnson and Rausser's equation (8) is proposed as an appropriate substitute for (1) in the two-variable case. In the general case their model can be written

$$(3) \quad Y_j = \alpha_0 (X_{1j} + b_j)^{\alpha_1} (X_{2j} + b_j)^{\alpha_2} \cdots (X_{kj} + b_j)^{\alpha_k} \exp(u_j),$$

where $b_j = 0$ if $X_{ij} > 0$ and $b_j = b$ if $X_{ij} \leq 0$. Also, the parameter, b, could be specified as unique to a given

independent variable, say b^i. The parameter b is treated as an additional parameter to be estimated simultaneously with $\alpha_0, \alpha_1, \cdots \alpha_k$.

Johnson and Rausser do not consider specification of the following model, which to me is much more logical:

$$(4) \quad Y_j = \alpha_0(X_{1j}+\beta_1)^{\alpha_1}(X_{2j}+\beta_2)^{\alpha_2}\cdots(X_{kj}+\beta_k)^{\alpha_k}\exp(u_j),$$

where $\beta_1, \beta_2, \cdots \beta_k$ are specified a priori on the logical basis of the particular variable in question. For example, a zero level on a factor in an agricultural experiment is usually defined on an arbitrary scale, thus changing the origin, and interpreting the results accordingly causes no problem whatsoever. In fertility experiments it often makes more sense to define the minimum level of a factor in the experiment as an estimate of the amount of nutrient available in the control plots. Often the β_i will be zero when there is no problem with negative or zero values of X_{ij}.

Very often (1) does not make any sense as one or more of the independent variables approaches zero, since obviously $X_i=0$ implies $E(Y)=0$ for any $i=1, 2, \cdots k$. As long as we remain in the framework of regression (as opposed to correlation), the independent variables can be defined on any measurement scale we please, with the origin arbitrary; the only relevant consideration is the algebraic form of the mean in the underlying population of the dependent variable. (Questions on the error term—multiplicative or additive—are deliberately avoided in this comment.)

If the model of (1) is chosen for its property of constant elasticities and (4) is being considered as a substitute, one does run into the obvious property of elasticities: Elasticity is not invariant with respect to the origin of measurement. This fact should make one aware of the limitations of elasticity as a summary measure of the structure of an economic entity such as a demand equation. But how far should we go to retain (1) as an empirical equation instead of (4), merely for the sake of constant elasticities? Should we expect the elasticity to change abruptly as the origin is approached? If our answer to the latter question is positive, the model of (4) is superior to (1) when the emphasis is on empirical estimation of elasticities. A diligent choice of the constant, β_i, added to the ith independent variable, X_i, can give us essentially constant elasticity, α_i, except near a zero value of X_i.

Johnson and Rausser's approach is a salvage operation for retaining the model of (1), but without an adequate reason given for keeping (1) in its pure form instead of a substitute model such as (4). We have an obvious discontinuity problem with their method. Suppose we are concerned only with the possibility of some zero values of X_1 in the sample data and we are dealing with only one independent variable. Then the conditional mean of Y is

$$(5) \quad E(Y \mid X_1) = \alpha_0 X_1^{\alpha_1}, \qquad X_1 > 0$$

$$(6) \quad E(Y \mid X_1) = \alpha_0 (X_1 + b)^{\alpha_1}, \qquad X_1 = 0.$$

In the vicinity of the origin for X_1, the graph of $E(Y|X_1)$ is depicted in Figure 1 under the assumption $0<\alpha_1<1$.

There is a discontinuity in the function, $E(Y|X_1)$, at the point $X_1=0$. Also, the relationship has the same value for two points on the X_1-axis: at the points $X_1=0$ and $X_1=b$, $E(Y|X_1)=\alpha_0 b^{\alpha_1}=$"$a$" in Figure 1. Thus, if we were dealing with a production function, an anomaly arises where output on the interval $0<X_1<b$ is less than at $X_1=0$. As we increment the factor of production from zero, output drops from a on the graph to essentially zero. Then as the factor is incremented further, output continuously rises until at $X_1=b$ it reaches the level a from which it started with $X_1=0$. How can such a relationship be defended? It would appear that this absurd situation in the neighborhood of the origin is too high a price to pay for salvaging (1) as a model when nonpositive values are present in the sample data. Instead of the salvage operation proposed by Johnson and Rausser, we should seek an alternative model such as (4).

It appears to me that Johnson and Rausser did not really intend that (3) be thought of as the model per se, but the idea was to use (3) as a means to achieve statistical estimation of (1) when nonpositive values are present in the sample data. However, such an approach begs the question. How can (1) be a consistent model when the nonpositive values in the sample data themselves violate the model? In order that (1) be consistent with a sample of data

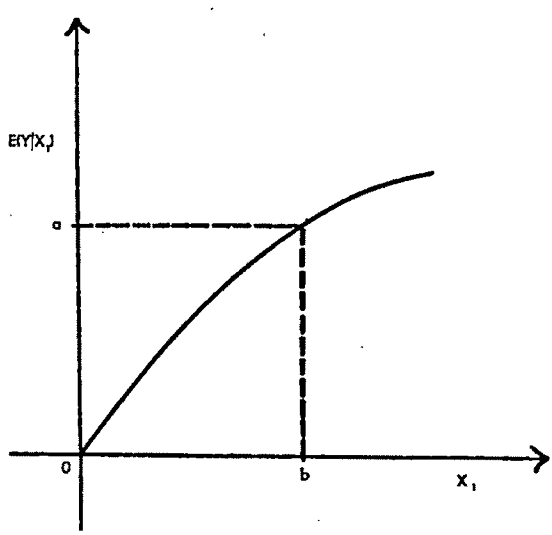

Figure 1

containing some zero values in the set of independent variables, the dependent variable would have to be zero for each zero appearing in an independent variable. Obviously any negative values of the independent variables force us to reject (1) for any sample.

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EFFECTS OF MISSPECIFICATIONS OF LOG-LINEAR FUNCTIONS WHEN SAMPLE VALUES ARE ZERO OR NEGATIVE: REPLY

Burt has suggested that his equation (4) is a more desirable "misspecification" of equation (1) than our equation (3) or, identically, equation (8) in our original paper [1]. There are two basic differences between equations (3) and (4): (i) In (3) b_j is estimated from the sample data while in (4) the $\beta_1, \beta_2, \cdots, \beta_k$ are specified a priori on the logical basis of the variable in question; (ii) the number of parameters differ in the two misspecifications. We shall discuss the importance of these two differences.

Regarding difference (i), Burt argues that the a priori specification of the $\beta_1, \beta_2, \cdots, \beta_k$ is superior to our estimated b because of liberties that can be taken in scaling the independent variables in regression analysis, the lack of consequence of elasticities calculated near the origin, and the discontinuity that takes place in the neighborhood of the origin. The first of these arguments can be handled quite easily and in fact was not discussed explicitly in our original paper because if such an a priori basis exists for respecification of the variables X_{ij}, then model (4) is in principle the same as model (1). The example regarding fertility experiments and the handling of observations from control plots is, as Burt indicates, an instance in which a respecification of the variables can be made without loss of the interpretability of the parameters. But what is the a priori logical basis for rescaling observations in consumer budget studies or in zero or negative values that occur in differenced data? In many cases such a priori information does not exist, and our approach can be employed if one wishes to retain a log linear model. In situations where the log-linear model is retained and there is little or no a priori basis for respecifying the X_{ij}, the natural place to look for required information is to the portion of the sample data that satisfies the log-linear hypothesis. That is, in this situation we suggest that the use of model (3) is better than scale-distorting misspecifications of the variables.

In the comment regarding elasticities it is suggested that our approach goes too far in trying to salvage constant elasticities of a scale consistent with the specification of model (1). It is a little presumptuous to suggest that researchers should always be willing to make sacrifices in terms of interpreting the elasticities. Obviously, this decision depends upon the application in question. We would agree that when a strong basis for respecifying the model exists the trade-off could be made. However, in the absence of such an interpretable respecification we would again argue that the approach suggested in model (3) is a viable alternative.

Finally, in connection with the discontinuity occurring in our method it is clear that such discontinuities occur in the vicinity of the origin. As usual, if (1) is not regarded as applicable for $X_{ij}=0$, the discontinuity problem is of no real consequence. In the case of (3), the relevant range of X_{ij} is $X_{ij}>0$ for all i, j. This is implicit in the approach we utilized. Furthermore, it is also implicit in Burt's specification (4) when abrupt changes in elasticity near the origin are excluded. Hence, the discontinuity, although unfortunate, is unlikely to affect the usefulness of the results. In fact, some of the comments made by Burt in justifying the rescaling as it relates to elasticities might well be reiterated here as a basis for admitting the discontinuity in the vicinity of the origin.

Difference (ii) in models (3) and (4) can be rather easily outlined. Note that in general, for nonstochastic b, the model may be represented

$$y_j = \alpha_0(X_{1j} + b_{1j})^{\alpha_1}(X_{2j} + b_{2j})^{\alpha_2} \cdots (X_{kj} + b_{kj})^{\alpha_k} \exp(u_j).$$

This model is, of course, nontractable[1] without the specification of some additional restrictions on the b_{ij}'s. In Burt's specification (4), the b_{ij}'s are permitted to vary across regressors but remain constant for all observations, i.e., $b_{ij}=b_{ij'}$, for all i, j, j'. For specification (3) the b_{ij}'s vary across observations but are constant for alternative regressors, i.e., $b_{i'j}=b_{ij}$ for all i', i, j. The latter specification could be generalized to accommodate the former at considerable expense in computational procedures and further restrictive assumptions. More specifically, the reason we did not include the possibility of b_{ij}'s varying across regressors is simply the complexity of the resulting derivations. It appeared that the implications of the simple model are sufficient to pro-

[1] The nontractability results from the unknown b_{ij}'s being equal to the number of observations times the number of explanatory variables.

vide a rough guideline for such misspecifications. The guideline was, of course, that the misspecifications should be such as to make the newly defined $X_{ij}+b_j$ as consistent as possible with the subset of the observations in the sample satisfying the hypothesis implicit in model (1).

Burt's concluding comments are surprisingly similar to our own [1, p. 124]. We noted that the application ". . . of a multiplicative functional form and the related log-linear estimation procedure is admittedly a precarious approach when sample data include negative or zero values in some of the observations on the independent variables. The hazards result largely from the inconsistency of the observed sample information with a maintained hypothesis of the type mentioned in connection with equation (1)." Burt's last two sentences also require some qualification. In situations where it appears reasonable to suggest that measurement errors result in zero or negative observed values, the b_{ij}'s could be specified as stochastic rather than population constants. In these situations an errors-in-variables model is required, and it is far from obvious that (1) ought to be rejected if negative or zero values of the independent variables appear in conjunction with positive values of the dependent variables.

To summarize our reply to Burt, we acknowledge the legitimacy of (4) as an alternative specification of (1) but point out that such respecifications rely heavily upon the availability of a strong basis for the rescaling of the individual X_i. Furthermore, when such possibilities exist, model (4) is for most purposes the same as (1). Our results apply more satisfactorily to situations in which such respecifications are less obvious. Our major point is that when a priori information does not exist the researcher may look at the portion of the sample satisfying (1) for some guidelines in connection with misspecifying the variables not satisfying (1) so as to minimize the effect of the resulting misspecifications on the estimated α_i.

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Reference

[1] JOHNSON, S. R., AND GORDON C. RAUSSER, "Effects of Misspecifications of Log-Linear Functions When Sample Values are Zero or Negative," *Am. J. Agr. Econ.* 53: 120–124, Feb. 1971.

POSITIVISTIC MEASURES OF AGGREGATE SUPPLY ELASTICITIES: SOME NEW APPROACHES: COMMENT

This note has two purposes: (1) to point out a statistically intolerable feature of the aggregate supply equation specified by Tweeten and Quance in [3]; (2) to clarify the phenomenon to which Breimyer alluded in [1].

The direct least squares model of the aggregate supply function specified by Tweeten and Quance used the index of aggregate farm output as the dependent variable and a productivity index as one of the independent variables. The productivity index was to reflect "changes in management and technology as well as fluctuations in productivity induced by weather" [3, p. 343] and is the ratio of the index of farm output to the index of agricultural inputs. The index of farm output used in the numerator of this ratio is the same index as that used for the dependent variable in the regression equation [5, p. 21].

That the dependent variable appears on the right-hand side of the regression equation should make one suspicious of the logical basis of the equation; in addition, serious statistical limitations are introduced by such a model. The model can be written as follows:

$$(1) \quad Y_t = \alpha + \beta(Y_t/X_t) + \text{(other independent variables)} + u_t,$$

where u_t is a random disturbance from the mean. The random component, u_t, is necessarily correlated with the independent variable, Y_t/X_t, since u_t is an additive component of Y_t in the same time period.

It is well known that when the disturbance is contemporaneously correlated with an independent variable, estimators of all parameters in the regression equation are biased if the independent variables are not orthogonal; if the independent variables are correlated, the bias persists asymptotically and the least squares estimators do not have the property of consistency. If the independent variables were uncorrelated, the asymptotic bias would apply only to the regression coefficient of the independent variable correlated with the disturbance term; but if an independent variable logically belongs in (1), it is necessarily correlated with Y_t/X_t.[1]

These statistical limitations would seem to be enough to discourage using such a model as (1), but we also ask the following question. How can one logically explain the variation in a variable over time by having the very same variable contemporaneously on both sides of the equation? That is, what sense

[1] For an analysis of these types of problems, see Goldberger [2, ch. 6, especially p. 282].

does it make to say that Y_t is some function of Y_t? It would seem that the logical and statistical limitations of the direct least squares model used by Tweeten and Quance negate any inferences that were drawn from it.

Breimyer's main point seems to be that interactions of demand and supply bias the supply response upward. Suppose that supply is assumed linear but in actuality there is no relationship between price and quantity on the supply side. Then Breimyer's proposition is that a regression analysis would very likely show a positive coefficient on the price variable. In my opinion Breimyer presents a good argument to support this proposition, but Tweeten and Quance in their reply [4] seem to disagree.

The bias involved is not simultaneous equation bias as usually defined, nor is it specification error of another kind; it is the bias associated with using lagged endogenous variables as predetermined variables in a simultaneous equation system. The bias dissipates as the sample size becomes large, but the small sample bias is a commonly recognized limitation in econometrics literature. This bias has probably been largely overlooked in agricultural supply analysis because of the recursive nature of the system; the supply equation seems completely satisfactory without any reference to the demand equation. Breimyer has pinpointed the bias in an able manner with his heuristic argument in [1]. We would like to see the bias quantified, however, which would remove any question about the direction of the bias and at the same time show its magnitude.

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[1] BREIMYER, HAROLD F., "Nature's Felicity in Supply Response Analysis," *Am. J. Ag. Econ.* 52:146–147, Feb. 1970.

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[3] TWEETEN, LUTHER G. AND LEROY QUANCE, "Positivistic Measures of Agregate Supply Elasticities: Some New Approaches," *Am. J. Ag. Econ.* 51:342–352, May 1969.

[4] ———, "Nature's Felicity, Specification Error, and Bias in Supply Response Analyses: Reply," *Am. J. Ag. Econ.* 52:150–151, Feb. 1970.

[5] U. S. Dept. of Agriculture, *Major Statistical Series of the U. S. Dept. of Agriculture, Vol. 2. Agricultural Production and Efficiency*, Agricultural Handbook No. 365, April 1970.

ON STATISTICAL INTOLERANCE IN SUPPLY ANALYSIS*

Burt alleges that it is "statistically intolerable" to include the output-input ratio on the right side of a supply equation explaining aggregate farm output. We propose: (a) that it is not only statistically tolerable but econometrically essential to include the ratio in the supply equation in order to avoid large bias; and (b) that there are advantages in estimating the aggregate supply elasticity from an input demand equation rather than from an output supply equation.

Before examining empirical estimates to test our proposals, it is well to review some fundamentals of supply function specification. An aggregate input demand function is a fitting point of departure. Widely accepted principles of classical microeconomic theory suggest that the input demand quantity is a function of relative prices of variable inputs and quantities of fixed inputs [1, p. 48]. The theory is embodied in equation (1), an explicit input demand function suitable for estimation in logs:

$$X_t = \alpha R_{t-1}{}^{\beta} S_t{}^{\gamma} \mu_t \tag{1}$$

Aggregate input quantity X is a function of the ratio R of prices received P_r by farmers to prices paid P_p by farmers (for production items including interest, taxes, and wage rates), the beginning year stock of productive assets S, and an error μ. R reflects the short-run impact of variable inputs, primarily cash operating units, and S reflects the impact of fixed inputs, primarily stocks of real estate, crops, livestock, and machinery.

Ordinarily, policy planning calls for knowledge of the response of output O rather than input X to price. While it is advisable to estimate empirically the elasticity of supply from the input demand function such as equation (1), for various reasons, including tradition, econometricians have derived supply parameters directly from a supply equation with output the dependent variable. By definition, $O = XT$, where T is O/X, the index of productivity or technology. Since empirical data provide no statistical evidence that T is a function of R (cf. [1, p. 447]), the response of output to price can be found from (1) simply by multiplying X by T. The supply function formed by multiplying both sides of the equation by T is equation (1″), where $\delta = 1$:

$$O_t = \alpha R_{t-1}{}^{\beta} S_t{}^{\gamma} T_t{}^{\delta} \mu_t \tag{1''}$$

Defining elasticities of input demand as $(dX/dP)(P_p/X)$ and product supply as $(dO/dP_r)(P_r/O)$, the general rule [3] (given $O = XT$, $X = f(R)$, $T \neq f(R)$, and $R = P_r/P_p$) is:

$$\frac{dO}{dR}\,\frac{R}{O} = \frac{dO}{dP_r}\,\frac{P_r}{O} = \frac{dX}{dR}\,\frac{R}{X} = -\frac{dX}{dP_p}\,\frac{P_p}{X}.$$

* Oklahoma Agr. Exp. Sta. Journal Article 2314.

Table 1. Equations estimated by least squares from annual U. S. data for 1922–1965 (excluding 1942–1947), showing coefficients, t-values, and related statistics[a]

Equation and dependent variable	Coefficient of determination	Constant	Independent variable coefficients					
			R $t-1$	T t	Time t	S t	O $t-1$	X $t-1$
2	.79	1.01	.13			.37		
X_t			(4.55)[b]			(10.51)		
2′	.99	− .88	.12	1.06		.25		
O_t			(4.33)	(17.56)		(2.24)		
2″	.91	−2.59	.18			2.12		
O_t			(2.03)			(18.94)		
3	.79	1.00	.13		−.00001	.37		
X_t			(4.48)		(−.019)	(3.93)		
3′	.99	−.94	.12	1.11	−.0003	.25		
O_t			(4.05)	(10.45)	(−.559)	(2.23)		
3″	.96	−.44	.20		.005	.89		
O_t			(3.38)		(6.80)	(4.53)		
4	.86	.14	.06					.87
X_t			(2.49)					(13.69)
4′	.99	−.56	.12	.99			.17	
O_t			(4.40)	(14.72)			(3.08)	
4″	.94	−.20	.13				.97	
O_t			(1.79)				(23.75)	

[a] See [2] for sources of data.
[b] t-values are in parentheses. A t-value of 2.03 is statistically significant at the .05 level; of 2.72 at the .01 level.

With the input demand and output supply equations specified, we now turn to empirical analysis. The equations in Table 1 are estimated by ordinary least squares from annual U. S. data for 1922 through 1965, excluding 1942 through 1947.[1] The equations were estimated in logs and in original values; results were very similar and only parameter estimates from the log equations are presented. Time, however, is in the original values, recorded as the last two digits in the current year.

To determine from the equations in Table 1 the bias introduced by omitting T from the supply equation, a norm is needed. Based on the conceptually more appropriate input demand equations, the magnitude of the short-run supply elasticity β is .13 or less. As indicated before, δ is approximately 1. The coefficient γ of S is essentially the elasticity of production for durable assets. The sum of the elasticities of production for components of S (stocks of real estate, crops, livestock, and machinery) is .42 from one estimate of the production function [2, p. 350]. Based on these norms, supply equations (2″) and (3″) estimated without T provide severely biased and unacceptable estimates of β and γ. On the other hand, the procedure of including T in the supply equation as in (2′) and 3′) provides reasonably acceptable estimates based on the norms discussed above. The coefficient of the beginning year stock of productive assets appears to be biased downward somewhat in (2′) and (3′), however.

The statistical bias introduced by errors in the independent variable T correlated with the disturbance μ and correctly cited by Burt is dwarfed by the specification bias from excluding T. If a supply equation is estimated, it should include T to minimize bias. But a better solution is to estimate the supply parameters from an input demand equation.

The coefficients of R (short-run price elasticities) in distributed lag supply equations (4′) and (4″) are in line with estimates in input demand equations (2) and (3). But these distributed lag equations provide highly biased estimates of the adjustment rate. The adjustment rate, 1 minus the coefficient of O_{t-1}, is .83 according to equation (4′) and .03 according to equation (4″). The former rate is unrealistically high; the latter rate is unrealistically

[1] Data for 1942–1947 were excluded in the original study [2]. The equations in Table 1 were initially estimated using data through 1969, but the more recent data were subsequently omitted because of large prediction errors that may be explained by outdated (1947–1949) prices used to weight quantities in the input and output indexes.

low. T is, of course, highly correlated with O_{t-1}. Because T is omitted in equation (4″) its impact is absorbed by the coefficient of O_{t-1}; the coefficient is biased upward and the adjustment rate downward. Including T in equation (4′) helps little because of markedly different adjustment rates of O_t to R_{t-1} and T_t. Because the adjustment rate of O_t to T_t is 1 and to R_{t-1} is approximately .13 (based on equation (4)) and because the specification forces the same adjustment rate for R and T, a compromise results that is too high an adjustment rate for R and too low for T. We rejected estimates from an equation similar to (4′) as unacceptably biased in our original study, and we still do.

Lest the argument for excluding T appears to be vindicated, we hasten to add that leaving out T leads only to intolerably large bias in the opposite direction. Whereas (4″) (without T) is unsalvageable, equation (4′) (with T) would appear to be salvageable by estimating the distributed lag form with one lag on R, another on T. With a forced adjustment rate of 1 on T, a least squares estimate of (4′) gives a coefficient of .06 for R_{t-1}, 1.15 for T_t, and .67 for O_{t-1}, implying an adjustment rate .33 of O_t to R_{t-1}. This adjustment rate is more acceptable than that in (4′) or (4″) but is probably more biased than the estimate from the input demand equation (4). The latter estimate that 13 percent of the adjustment of quantity to price is made in one year implies that long-run elasticity is approximately 8 times the short-run elasticity.

In short, results in Table 1 (assembled in response to Burt's comment) indicate a short-run elasticity of supply of approximately .1 and a long-run elasticity about 8 times the short-run elasticity. In our earlier study we concluded that the supply elasticity is .10 in the short run and .80 in the long run for decreasing prices; .15 in the short run and 1.5 in the long run for increasing prices [2, p. 351]. The results in Table 1 are not inconsistent with the earlier results, and we continue to endorse our earlier estimates interpreted from several approaches as the best measure yet available of the short- and long-run supply elasticities.

Some refinements in the estimating procedure would be useful. However, inclusion of time, government payments, and diverted acres as independent variables did not result in significant coefficients or improve the estimates in Table 1. A first-order autoregressive scheme also failed to improve the estimates.

In answer to Burt's second point dealing with Breimyer's comment, we do not concede that interactions of supply and demand bias the supply response upward. Like Burt, however, we would like to see the issue quantified.

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INACCURACY IN REPORTING BY HILLMAN

An inaccuracy appears in a recent statement by Hillman [2, p. 637] which begins, "Moreover, when one calls for the preservation of the family farm on the basis of its superior results in morality and democracy as well as efficiency and economic organization, as did Farris in a recent article. . ."

Actually my comments about morality and democracy were not as indicated by that statement. In the article to which Hillman referred I said with respect to morality,". . . the case for preserving the family farm will need further arguments on its behalf." And with respect to democracy I stated, ". . . we again must look further in order to justify saving the family farm" [1, p. 25].

In other words, my essential point on criteria for evaluating the family farm was that arguments of morality and democracy were inadequate to demonstrate superiority. I concluded, as correctly reported in a USDA news release on the article [3], that the most forceful argument involves none of these virtues; it is that of supporting decentralized decision-making and diffused economic power in the organization of society.

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[2] HILLMAN, JIMMYE S., "On Returning from Our Agricultural Babel," *Am. J. Agr. Econ.* 52:635–644, Dec. 1970.

[3] U. S. Department of Agriculture, Office of Information, *USDA Farm Paper Letter* 1333, Feb. 10, 1969.

INACCURACY IN REPORTING BY HILLMAN: REPLY

Touché! To be sure, a literal reading of my text and the sentences quoted by Farris leaves me with little defense. However, what Farris fails to mention in his note is the variety of pictures of a farm family, of Thomas Jefferson, and of an obvious "family farm" layout, plus the copious quotes and citations from those obviously sympathetic to the family farm idea. One can hardly get a message contrary to what I read ever so quickly.

Nevertheless, touché!

JIMMYE S. HILLMAN
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PETER KILBY'S REVIEW OF *STRATEGIES AND RECOMMENDATIONS FOR NIGERIAN RURAL DEVELOPMENT, 1969/1985*

Peter Kilby's review of our efforts [1] is particularly satisfying. He noted that we had accomplished the objectives of our research contract with respect to policy measures, output projections, costs, administrative arrangements, and the development of program recommendations that lend themselves to direct implementation. We are grateful for his review.

Kilby also made a valid point when he stressed the effectiveness and low cost of field studies of the type done by Welsch, Anschel, Thodey, Wells, and himself. (He might also have added Miller, Oluwasanmi, Norman, Essang, and others.) More such field work would have been done by the Consortium had the contract placed heavy emphasis on it and had not Nigerian military operations precluded field work for long periods in important geographic areas.

Kilby also stressed the large amount of resources used by the Consortium; in fact, he overestimated the cost of the project by several fold! While such overestimation biases his input-output ratio estimates for the project rather badly, his basic point is valid: agricultural sectoral analyses are expensive. We doubt that they will be made much cheaper (only better) by large numbers of the "old-fashioned foot-slogging studies" he stressed, valuable and important as such studies were in our effort. The high costs involved in agricultural sector studies result from the hard, tedious, complicated, exasperating task of "getting it all together." It will be possible to do this at lower cost in the future with the Consortium experience now at hand. Also, if done with indigenous personnel the costs can be lowered still further. However, as we see it, the main need is for a more effective way of getting it all together without accepting constraints on kinds of information used or becoming bound by the limitations of specialized techniques, i.e., recursive LP's, simultaneous equations, input-output analyses, cost-benefit analyses, Cobb-Douglas studies, etc. To this end AID and MSU have been engaged for over three years in disciplinary research on a "generalized computerized, systems-science simulation approach" to agricultural sector analysis. This work now suggests that the cost of agricultural sector analysis limited to the type and quality reviewed by Kilby may be cut over the next ten years by as much as 90 percent from CSNRD levels even when done by expatriate personnel.

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Reference

[1] JOHNSON, GLENN L., O. J. SCOVILLE, GEORGE K. DIKE, AND CARL K. EICHER, *Strategies and Recommendations for Nigerian Rural Development, 1969/1985*, review by Peter Kilby, *Am. J. Agr. Econ.* 53:375–376, May 1971

Reviews are listed alphabetically by authors.

Reviews

Brewster, John M., *A Philosopher Among Economists*, edited by J. Patrick Madden and David E. Brewster, Philadelphia, J. T. Murphy, 1970, vi + 294 pp. ($7.00)

This book is about basic beliefs and their influences on personal economic behavior, the shaping of policy and rules, and the social goals and structure that conditioned the growth of rural America. The setting is the "new lands" of mid-America and the West, with final application of the principles to the problems of the developing nations. It is a selection of 12 published and unpublished articles and papers from the voluminous works of the late John M. Brewster, a philosopher who worked through much of his career among economists of the U. S. Department of Agriculture. The task of the editors was challenging and demanding. They succeeded admirably, enabling Dr. Brewster in one short book to relieve significantly a deficiency in the education of many Ph.D. agricultural economists who have never had a formal course in philosophy.

The papers are arranged in three groups: "Belief and Values in American Democracy—Origins and Emerging Problems"; "Agricultural Policy Problems and Family Farms"; and "Economic Development and Cultural Change." Chapter 1, "The Cultural Crisis of Our Time," provides primary concepts, definitions, relationships, and ideas that reappear throughout the rest of the book. Culture is defined as the "heritage of belief systems people use in guiding their striving for individual and collective significance"; the striving is universal, but people differ in their beliefs concerning what is significant. Thus the beliefs are the cultural variables and the striving the cultural constant. Cultural change arises when circumstances demand changing the relative values of beliefs, leading to policy problems that are resolved by compromise in a society held together by common conviction. A cultural crisis occurs when the beliefs themselves are threatened.

The belief system inherited from the 19th century included the American Dream—the sense of destiny, wherein the example of her achievement would attract the rest of the world to following her own path, and the conviction that "he who governs least governs best" is the best form of political economy. The latter was supported by three other belief systems, the democratic ethic, the work ethic, and the enterprise ethic. The chapter traces the origins of these beliefs, shows how their relative values changed in response to changing industrial organization and the occupation of the frontier, and defines the elements of the crisis that had dominated the 20th century since about 1920.

That paper appeared in 1963, after about 10 years of study, analysis, and writing about the subject. The following three chapters are unpublished manuscripts from early in that period, providing deeper background and broader analysis of important aspects of the crisis. The last, on the American Dream, is an especially strong treatment of the romanticism basic to the work and enterprise ethics and the sense of destiny.

In the next group of chapters he outlined the phenomenal growth of output and productivity in American agriculture that led to excess output in the United States and gave hope to the rest of the world that the curse of the Malthusian law could be broken. He observed that by 1920 the surplus problem led to equality of income as the issue. A conflict ensued between farmers' beliefs in equal opportunity and freedom to manage their businesses as they pleased. After a discussion of the place of economists in measuring alternatives, he explored the Jeffersonian dream of the family farm.

Two chapters are of particular interest to researchers. The first is from a review and critique of a workshop in interregional competition. He had faint praise for the "progress toward building interregional competition theory into predictive knowledge" but had hopes "5 to 10 years hence." The major part of this paper is devoted to the interdepen-

dence of policy problems and research problems, emphasizing the neutrality of research. The second is "Philosophy: Principles of Reasoning Especially Applicable to Science." Of this the editors say, "He showed that the scientific method includes a considerable amount of art or genius in addition to the inductive and deductive thought processes."

In the first of two chapters on economic development the Great Plains provides the example of technical advance leading to a conflict of values arising from the expansion of farm size required for "proficient use of their labor and management and high powered equipment" versus the "system of small towns and related institutions, such as the district school, the village church, and local government." "In line with historic proficiency concepts, they (the people of the farms and small towns) heartily embrace the requirements of their new technologies for radical change in their 19th century economic institutions. But in line with rural fundamentalist attitudes, many seemingly stand as a wall against requirements of the same technologies for change in the 19th century systems of social and political institutions."

In a paper published posthumously Brewster looked at the developing nations. He saw the overall problem as a dichotomy: What are the central human barriers (1) to the technological requirements of progress and (2) to the organization requirements of increasingly productive technologies? He found the literature on development concentrating on the first question, but with widely divergent views. The second problem is centered in traditional kinship and village loyalties and distrust of those beyond. He postulated that an understanding of the interaction of the cultural constant with entirely different sets of cultural variables would lead to improved understanding of social systems in relation to growth processes.

I recommend this book to my fellow economists because of its logic, its breadth, its complete relevance in a rapidly changing world whose problems directly relate to the pressure of technology on beliefs, and what it tells us about ourselves.

Not only can the reader insert the realities of his own experience and observations in many of the situations about which Dr. Brewster structured his thesis, but the events of today take on new meaning. We have seen Dr. Brewster's cultural crisis become a cultural revolution. Youth, and many of the not so young, are questioning and abandoning old beliefs. What about the American Dream? Can the democratic ethic, the work ethic, and the enterprise ethic lead us to fulfillment in this new world of ours? The current rhetoric reflects the search for a set of cultural variables—beliefs and their relative values—that are relevant in the modern world. Not until these are settled will a new stability be achieved.

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Brown, Dorris D., *Agricultural Development in India's Districts*, Cambridge, Harvard University Press, 1970, xvi + 169 pp. ($10.00)

This volume deals mainly with India's Intensive Agricultural District Program (IADP). IADP was started in 1961 in a progressive district in each of 15 states as pilot tests and demonstrations of the possibilities of accelerating India's agricultural output through provision to farmers of increased technical assistance services along with increased market supplies of inputs. The author, formerly a U. S. extension economist, served for seven years in India as an advisor on IADP. Hence this volume has been eagerly awaited by his former colleagues in India who remember its author as an early staunch protagonist of and able contributor to IADP.

This volume should be read by all who are concerned with agricultural development in newly developing countries. For it contains much statistical information on most of India's 320 districts not readily available elsewhere, a lucid although brief review of Indian agriculture through the ages, an excellent description of the setting of IADP and of its organization and operations, an extensive bibliography with many listings of excellent Indian writings not well-known outside of India, and the author's evaluation of IADP.

The author concedes that IADP has helped to identify major structural constraints to increasing India's agricultural production and has thereby given direction and impetus to policies and programs putting emphasis on improving available technologies, expanding area under irrigation, and other long-run changes. He finds, however, that growth in output in IADP districts has been neither more nor less than in many other of India's districts. Some readers may interpret this to mean that IADP has had no beneficial effect upon the level of production over the period 1961–62 to 1965–66 in the IADP districts; hence a note on the author's methodology is warranted.

The author has arrived at his conclusion by (a) simple comparisons of the average annual output in IADP districts between 1961–62 to 1965–66 and the preceding five years and (b) similar comparisons between IADP and most of the rest of India's 320 districts. Assuming reliability of the statistics used (not in question), such comparisons would warrant the conclusion that IADP has had no beneficial effect upon production in the IADP districts only if all of the following "control" conditions had been closely approximated: (1) if at the outset of IADP, farmers in the IADP districts were no closer to economically optimal levels of performance than they had been at the start of the preceding five-year period; (2) if at the outset of IADP, farmers in the pilot districts were operating at the same point on a general production possibility surface applicable alike to IADP and other districts in the same state; and (3) if the shifts made in production possibilities

from 1961–62 through 1965–66 as a result of development activities other than IADP had been the same in IADP and other districts.

That none of these three conditions was fulfilled is readily evident from a careful reading of this volume. Hence, to have measured IADP's contributions to output in the IADP districts would have required, instead of the simple comparisons, analytical procedures designed to separate the influence on production of IADP operations from the influence of other differences and development activities. Had this been done, the present volume could have fulfilled in most if not in all respects the full implications of its title, *Agricultural Development in India's Districts.*

Hence, while the author is correct about the relative changes from 1956–57/1960–61 to 1961–62/1965–66, it does not follow that output has not been higher in IADP districts from 1961–62 to 1965–66 than it would have been without this program.

Furthermore, in assessing the author's findings, readers will need to keep in mind the facts (1) that IADP was in process of organizing, staffing, and training its staff throughout the first two years of its existence; and (2) that the year 1965–66 was marked by the worst general drought of this century, which, although no more severe in IADP than in other districts, was particularly unfavorable for IADP objectives.

IADP has now been in operation five years since 1965–66 and (as noted by Dr. S. R. Sen in his foreword to this book) has recently been subjected to a critical appraisal by an official evaluating agency. Nothing in these subsequent experiences indicates that technical assistance and services, including agricultural extension, are a panacea for modernizing Indian agriculture. But that such activities are important not only for speeding the dissemination of knowledge of improved technologies to farmers but for the feed-back of information needed for the direction of agricultural policies and programs generally, including research, is beyond question.

However, achieving an economically desirable balance in allocating scarce resources between agricultural extension services and other kinds of development activities is a continuing problem in India and in developing nations generally. In further research directed to this problem, one could hardly find a more relevant body of experience than is available in IADP operations over the last 10 years. It is as a portrayal of the conception of IADP and of its early growing pains in a nation beset with many critical social, economic, and administrative problems as well as a harsh physical climate, rather than as the final word on IADP contributions to India's agricultural development, that this volume will be of lasting value.

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Cline, William R., *Economic Consequences of a Land Reform in Brazil*, Amsterdam, North-Holland Publishing Co., 1970, xv + 213 pp. ($14.00)

This book shows theoretically and empirically that reforms which redistributed land from large farms to smaller farms would, under the conditions of the study areas of Brazil, increase agricultural production. In view of the CIDA studies and the now extensive literature on land reform in Latin America and elsewhere, this conclusion is not startling. However, this book is valuable for its orderly, systematic methods in treating what once was and for a few still is a value-charged area of investigation.

The conclusion that land redistribution causes increased production stems from two empirical relationships: (1) constant returns to scale and (2) greater intensity of land use on smaller farms. Cline first presents his theoretical structure in a single chapter. He examines possible causes and effects in considerable detail, so that later chapters concentrate on empirical tests and interpretation. In calculating scale economies, for example, he distinguishes efficiencies in use of only those resources actually employed in an activity from efficiencies when all the resources of the farm are included. Large farms using only a small percent of their land are likely to operate under decreasing returns; therefore, to be conservative, he tests his hypotheses on economies to scale on the resources-actually-employed basis.

Using data from three surveys, one taken by the author, Cline assembled information on 18 "product sectors" representing about one-third of Brazil's total production. Statistical tests showed that the Cobb-Douglas production functions differed from homogeneity of degree one in only 3 of the 18 sectors. In only one sector (a coffee sector) were there increasing returns. He also found no difference in efficiency between owner and nonowner tenures.

Cline hypothesized that land is used more intensively on small farms and that this intensity is not accounted for by land quality. This hypothesis was tested by regressing farm size against: (1) percent of productive farm area; (2) value added per farm area; and (3) inputs of land cultivated, labor, seed and fertilizer, and capital. Percent of productive farm area was related negatively to farm size in every sector, with estimates significant at the 5 percent level. The value added per farm is also related negatively to farm size in every sector but one (a sugar sector). Finally, with the exception of a few sugar sectors, almost all factors of production are applied less intensively as farm size increases. By three different tests, therefore, land use intensity declines as farm size increases.

He then examined agricultural production resulting from land redistribution. The effects of reforms were calculated on two bases: (1) a total reform that redistributes all land evenly and (2) a partial reform that affects only farms with over 300 hectares. Be-

cause Brazil had not implemented land reform, the analysis of its effects was necessarily on an "if-then" basis. He analyzed the effects of the reforms separately for each sector, i.e., no intersectoral reallocations. He defined new farm units as the land area of the sector divided by the number of families in the sector, including unemployed. He estimated the effects of reforms under assumptions of high and low levels of unemployment and changes and no changes in sectoral levels of seed, fertilizer, and capital.

The effects of the total land reform on production are negative in only 2 of 17 sectors and are substantially favorable in most of the other sectors. Under the partial reform, most gains by land reform were less than under total reform, but four sectors showed substantial gains and only one showed substantial reduction in production.

I hesitate to refer to assumptions—they are the necessary prerogative of the analyst—but one assumption bears significantly upon the outcome of the reform evaluation. Land price is used, in the partial reform, as an index of quality because "it is the only index of land quality for which data are available." If the value of land is its cost-saving efficacy, as Hawtrey has stated, its value might better reflect the supply of other factors or the condition of production rather than some inherent quality of land productivity. The "high-quality" land that qualifies for expropriation in the partial reform may exist precisely in those areas where less gain could be made by means of reform. Cline admits that his assumption is conservative, but it may be even more conservative than he intended. That he emerges with a positive effect for land redistribution is almost surprising.

If the case were to be made in favor of land reform, however, Cline's analysis does present a strong argument. This case is best stated in his own words: "Since the impact of reform even on conservative assumptions is not negative except in two sectors, it may be said that if land redistribution were undertaken for reasons of social equity alone, the production results would not be injurious to the economy."

Among the alternatives to land redistribution discussed and dismissed are "conventional policies" of product and input pricing, credit, extension, and storage; land taxation; and rent control. These measures, for one reason or another, according to Cline possess difficulties. In any event they are not really alternatives in the sense of policies that would preclude land redistribution.

The book is based on the author's dissertation, a fact revealed in the preface, no doubt to frighten away all but the most dedicated of graduate students and reviewers. As such, the style is mechanically explicit (no dust on his blossoms). It is well organized and carefully presented. If you are interested in Brazil or land reform, and especially in both, you should read this book.

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de Farcy, Henri, *L'Économie Agricole (The Agricultural Economy)*, Paris, Éditions Sirey, 1970, 446 pp. (56F, postpaid 61F).

The author is professor at the Institute of Social Studies of the Catholic University of Paris. He is a member of both the French Academy of Agriculture and the Academy of Commercial Sciences. Rather than dealing with abstractions of pure theory the book discusses the situation and role of agriculture in today's society, specifically the role of the ever-decreasing number of persons still living on farms in advanced countries of Western Europe and producing the food vital to others living off farms. Thus it looks into new kinds of services farmers can offer to the city people of ever-growing, crowded, and polluted urban centers in need of such scarce resources as fresh air and pure water and of "rural evasion" for the sake of better health and equilibrium.

There are only scant references to the problems of agriculture in the developing economies. In advanced countries, however, the author argues, technological progress with its powerful means has revolutionized agriculture. It has increased managerial risks, led to a drastic reduction in the labor force engaged in agriculture and wrecked the precarious equilibrium between supply and demand. The book presents a lively analysis of the multiple economic, social, and political aspects of the agricultural economy struggling for survival in the sixties. It includes a wealth of references, data, and cases in point. The role of agriculture in the world economy, its outlook, and the relative decrease in importance of nonfood industries supplied by the agricultural sector are also discussed within the context of other possible sources of food for mankind.

The discussion of the human and social behavior of people engaged in agriculture—their incentives, motivations, and desires—is most interesting. Productivity (ways and means to increasing it as well as its limitations) and the economics of production as it is affected by technological progress are, with an emphasis on research, the backbone of the technical chapters of the book. The chapter on demand for food and other agricultural products and the farmer's negligent attitude towards the laws of the market is well taken. The discussion of the problems of marketing is complemented by a penetrating look into the management of the agricultural production unit, including data collection, farm budgeting and accounting, and linear programming analysis.

Agricultural income problems are discussed, and farmers' low income levels, worldwide, are compared with those of other economic sectors; the main rea-

sons given for the disparities being the poor political and social organization of agriculture, population pressure on land, and unfavorable terms of trade. From the comparison between small-scale farming and medium- or large-size farms, the author moves to analyzing the possibilities offered by farmers associations and/or cooperatives of production and consumption. The need for increased capital investment is emphasized. Credit institutions, their growing role, and their prospects are properly examined. The increasing role of government in defining and enforcing agricultural policies is well illustrated by the impact of European Common Market's regulations upon the agricultural policies of its member states. The last part of the book deals with the integration of the agricultural economy in the overall economy, at country and world level; the difficult adjustment of a country's agricultural production to world demand; the increasing role of governments in organizing commodity markets; and lastly, the relationship of agriculture to the country's overall resources development in economic and human terms.

Though they may have some reservations about some of the author's judgments bordering on "fundamentalism" and some of his bold comparisons, those who read French will undoubtedly enjoy reading this book.

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Evenari, Michael, Leslie Shanan, and Naphtali Tadmor, *The Negev: The Challenge of a Desert* Cambridge, Harvard University Press, 1971, x + 345 pp. ($15.00)

The Old Testament, the Nitzana papyri, and other ancient literature, together with ruins from earlier occupants, demonstrate that people cultivated lands of the Negev at least 4,000 years ago. Agriculture evidently grew in peaceful times and contracted with depredations by nomadic raiders or with the oppressiveness of taxes levied on settlers by alien forces. Outside forces (human actions), not climate or soils, caused the decline and eventual abandonment of this arid environment.

"The purpose of this book," according to the preface, "is to summarize two decades of scientific study in the Negev desert by the authors and to lay open our conclusions to criticism and discussion. . . . Our immediate motivation was the settling of the Negev desert, but our wider objective always included searching for generalizations that would help other people to solve similar and related problems in other arid regions. . . ."

The Negev is part of the Old World Desert belt that extends from the Sahara through the Arabian to the Sind of India. Study was concentrated in the Israeli-owned portions, forming a triangle with its terminal points near Gaza on the Mediterranean coast, Elath near the Red Sea, and in the area of the Dead Sea. This area has no "average" rainfall. Years of absolute drought are interspersed with others having up to 150 millimeters (approximately 6 inches) of rainfall.

Two ancient farmsteads located at Shivta and Avdat—almost in the middle of the triangle—were the bases for actual studies in hydrology, engineering, soils management, and crop production. The two sites were discovered and outlined through study of aerial photos and archeologic exploration. Relic water diversion systems designed to collect periodic hillside runoff and channel it to lower-lying fields were redefined, as were old field boundaries, chains of shallow wells, cisterns, farmsteads, and other types of structures used by previous occupants.

Plant species known to have been cultivated in the area during the 6th and 7th centuries A.D., and also some more recent introductions exotic to the specific environment, were selected for study in experimental plots. Most of the crops prospered under the reconstructed farming pattern, in spite of prolonged drought, desert heat, and occasional floods. The authors emphasized that an almost infinite variety of critical relationships within small areas requires masterful adaptations in management practices for successful culture under desert conditions. A mass of technical detail is compressed into the 18 chapters, the foreword, and the epilogue. Most readers probably would not grasp the many specifics about landforms, geology, or plant and animal physiology. Yet, who can say which of these details is insignificant to the whole complex of knowledge needed for successful farming under such harsh environmental constraints?

Experience gained here, according to the authors, demonstrates that the desert can be made fruitful for man through wise use of resources locally available. Large-scale production and development of closely knit communities are, as yet, unrealized dreams.

Economics is hardly mentioned in the book. Or perhaps one might suggest that the whole study reflects an economics of desperation. The engineering techniques and the cultural adaptations that seem to work in the Negev apply to a situation beyond the usual margins for commercial agriculture. The economics of such situations are beyond our conceptions of feasibility, viewed from a nation chronically burdened by overproduction from modern mechanized agriculture. Desperation economics applies in many areas of the world where population presses on resources. How can a "have not" people capitalize on technical skills and site situations to overcome climatic constraints? Worries about economics may come after the biological and engineering aspects of production under desert environments have been mastered; but first things first!

Minor irritations of the publication, such as the small scale of many line drawings, metric scale measurements, and a superabundance of information, should not deter economists interested in arid land development from serious study of the relationships and implications developed by the authors in this book. Their thoughtful and painstaking efforts are in the best research tradition.

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Griffin, Keith, *Underdevelopment in Spanish America: An Interpretation*, Cambridge, Massachusetts, The MIT Press, 1969, 288 pp. ($10.00)

This book consists of a series of loosely connected essays dealing with the economies of the nine Spanish-speaking countries of South America. The author clearly associates himself with the school of radical political economists who have come to believe that "underdevelopment is a process that is sustained by existing national and international institutions" and that "if rapid development is to occur, these institutions must be altered" (Preface). In the final chapter, which draws together the conclusions of the essays constituting the rest of the book, he concludes that "the essence of development in Spanish America consists in converting the constants of marginal analysis into variables" (p. 269).

The introduction, which deals with "Underdevelopment in Theory and History," is highly critical of much of the standard development theory, including dualistic growth models, stage theories, and the role of international trade and investment in economic growth. The historical analysis contained in the introduction (which is not confined to Spanish America but rather deals with the whole Third World), and elsewhere in the book, suggests that the kind of structural changes he advocates have occurred most often when the ties of the region to the world economy were severed. The theme of "unequal partners"[1] and the dependency relationships implicit in it runs throughout the book and leads to the conclusion that ". . . foreign contact between two grossly unequal economies may help to create underdevelopment, while the lack of contact may permit—but does not insure—development" (p. 270). Development and underdevelopment are thus seen as being directly related rather than independent of one another. International trade and investment, far from being a smoothly functioning engine of growth, are seen as having destructive as well as constructive influences upon economies dependent on the international economic system.

Besides the introduction, which is a chapter in itself, there are seven chapters dealing with the social and economic structure of Spanish America, resource transformation and foreign trade, capital imports and national development, mixed enterprises and foreign investment, inflation and exchange rate policy, regional integration, and the relations between Spanish America and the industrial west.

Agricultural economists will find their appetites whetted by Griffin's assertion in chapter 1 that the agricultural sector has been the principal factor restraining development in Spanish America; but beyond a predictable call for radical land reform and rural public works projects there is little in the book of professional interest if this is narrowly defined. On the other hand, Griffin shows considerable skill in manipulating the tools of traditional economic analysis, if only to show their inadequacy in dealing with problems that he sees as being as much political as economic.

Chapter 2 concentrates on the "transformation problem" existing in a number of Spanish American countries—the relative immobility of resources between sectors, particularly in natural-resource-based industries and tree crops. The transformation problem, together with institutional rigidities such as those inherent in the latifundia-minifundia system, contradict some of the fundamental assumptions of neoclassical trade analysis. A combination of transformation problems and low-income elasticities of demand for many primary products is seen as "deadly."

In place of the traditional analysis, which assumes away many of the most relevant problems for development, Griffin calls for a greater emphasis on political economy; for example, an examination of which groups in society reap the major benefits from international trade. In this case he finds that foreign-owned enterprises in the export sector, governments in need of tax revenues, and workers in such enterprises constitute strong vested interests in perpetuating existing patterns of trade. Owners of large tracts of land producing export crops fall in the same category.

The role of foreign aid and investment in promoting or retarding development is discussed at some length in chapter 3. The general set of the approach is given at the beginning: "The problem of these countries is not so much 'growth,' i.e., expansion of a given socio-economic system, as it is 'development,' i.e., rapid and fundamental politico-socio-economic transformation" (p. 117). Griffin proceeds to develop his argument in the context of a Harrod-Domar type growth model incorporating foreign capital flows explicitly. His conclusion that "if capital imports lead to lower domestic savings . . . a country that relies on foreign assistance may become permanently dependent and incapable of self-sustained growth" (p. 122) is correct, but the reasoning leading to this conclusion has logical flaws and inconsistencies. His assertion that "foreign assistance can be successful in accelerating long-run growth only if it raises the marginal propensity to save" contradicts

[1] Griffin appears to have been influenced by Balogh's work; see [1].

the (incompletely developed) mathematical model he uses, a more complete exposition of which may be found in one of his references [2]. That source shows that, on the contrary, greater foreign assistance will increase the growth rate, though a necessary condition for ending capital inflows is that the marginal savings rate exceed the average rate. If, as Griffin suggests, foreign aid reduces the marginal savings rate, the necessary condition for permanent dependency at a given target growth rate is that the reduction in the marginal domestic savings rate be sufficient to reduce it below the average savings rate.

His finding (based on observations for 15 Latin American countries for the period 1958–1964) that there is a tendency for gross domestic saving as a percent of gross product to fall as capital imports rise does not necessarily show any causation in the direction he postulates; in fact, one could just as well make the argument that it is precisely because of their low domestic savings rates that these countries sought foreign assistance. Although I am inclined to suspect that the causation, if any, goes in the direction suggested by Griffin, I do not think he has proven his point. Furthermore, the whole argument is based on the existence of a target growth rate that is presumed to be independent of the amount of foreign assistance expected to be available. Only in this case could one possibly regard domestic saving as a residual, as Griffin asserts (p. 122).

He goes on to discuss the effect of direct foreign private investment on social coherence and entrepreneurial initiative, suggesting a number of important negative effects, and also points to the utility of "ideological fervor" in rendering acceptable the consumption sacrifices implicit in the development process, noting that foreign investment is "not the type of activity which generates and sustains an ideological fervor; this is something which only domestic efforts can produce" (p. 132). One is inclined to laugh at this statement which dismisses the popular support behind nationalization campaigns (such as that involved in the formation of Petrobras in the 1950's in Brazil, copper in Chile, or the IPC case in Peru) as unrelated to the presence of large and conspicuous foreign investments.

Chapter 4 on "Mixed Enterprises and Foreign Investment" is essentially a cost-benefits analysis of the "Chileanization" program of the Frei government for the principal copper mines. It is of considerable interest given the nationalization policy of the present Popular Unity government, though it appears that the findings are rather sensitive to the discount rates and international copper prices assumed as well as the technique of compensation.

Chapter 5 on "Inflation and Exchange Rate Policy" once again makes use of a modified Harrod-Domar model from which Griffin extracts a number of useful insights that are relevant to the current debate on employment policy. Griffin finds that "the crucial task of development policy consists in finding an optimum combination of private investment, growth-inducing consumption, and public capital formation" (p. 192). Analyzing the effects of inflation in the Spanish American setting, he shows that governments are unable to operate an efficient inflationary (forced savings) policy and comes to the rather orthodox conclusion that "the time has come to stop trying to live with unplanned inflation and start planning to live without inflation" (p. 203). His subsequent attacks on traditional stabilization policies will reassure good radicals, though the solution (which seems to involve multiple exchange rates and a "crawling peg" if not flexible exchange rates), while sensible, must be considered part of the conventional wisdom today.

Chapter 6 on "Regional Integration" is largely a summary of the literature on this topic and contains little in the way of original analysis. It is nevertheless a good review, with appropriate insights concerning the political and economic problems of economic integration in the region.

Chapter 7 pulls together the rather diverse findings of the rest of the book in a convincing and coherent manner. The dependence thesis and the radical conclusions to which it leads are clearly stated. Having concluded that "in the final analysis, the region's poverty is a reflection of the politics of the past," he goes on to assert that "an attempt now to develop in Spanish America depends upon political processes (and whether they will be violent or evolutionary is unknown) as much as upon economic decisions" (p. 281). Not exactly a ringing call to the barricades, one must say, although the implications of the book are that revolution is not only justified but necessary.

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Iowa State University Center for Agricultural and Economic Development, *Benefits and Burdens of Rural Development*, Ames, Iowa State University Press, 1970, xii + 311 pp ($5.95)

U. S. public policy towards agriculture has historically been made up of two general sets. The first, pursued for over a hundred years, has been developmental in nature and is represented by public effort and investment to increase the supply and reduce the cost of resources to agriculture. The second, mostly of recent vintage, has been compensatory in nature, attempting to offset certain effects of the developmental policies with supply control programs, support prices, and nonrecourse loans, and international food shipments and direct payments.

The papers included in this book are directed to the second set of policies, and more generally to the problem of the distribution of gains and losses from the kind of economic development the U. S. economy has experienced. The topic is especially timely as we shift (at least temporarily) from a concern with obtaining higher rates of aggregate growth to a concern with how that growth is shared. Increasing concern for the disadvantaged and marginal groups in the United States recently has caused economists to give increasing attention to how the benefits of development are distributed and to how that distribution might be improved. This collection of papers is a useful contribution to that analysis. Added relevance to work of this kind is provided by the growing recognition that the benefits of new technology, clearly an important source of growth, are not being widely shared when technology is used as an instrument of development in low-income countries.

One of the themes of the book is that technology, which has been the major policy instrument for the development of U. S. agriculture, benefits most those who already have ample resources. The nature of the technology, plus the economic conditions surrounding agriculture in a growing economy, have required that the labor force bear a major share of the adjustment costs of the new technology and of the development that results from its application. A second theme of the book is that public policies, which might have facilitated the adjustment or at least partially redressed the imbalance, have for the most part aggravated the problem. These policies have tended to ignore labor and its adjustment problems, while protecting or increasing the asset values of other resources, and sometimes have resulted in substantial capital gains to those who have already benefited from the new technology.

The book contains 16 chapters prepared by 23 different authors, hence does not lend itself to a detailed critique. A flavor of the topics covered can be obtained from the titles of its four parts:

I. Some General Economic and Social Characteristics of Rural Communities
II. Effects of the State of Growth and Technology on Rural Communities
III. Economic and Social Policies for Improvement of Rural Living
IV. Public Policies to Relate Welfare of Rural People to National Goals

When viewed as a whole this is a troublesome, frustrating volume. In some respects it is meaty and pertinent, and some of the papers make excellent contributions. Certainly its theme cannot be faulted on its relevance. On the other hand, the book is rather badly organized and uneven in quality. The reader searches in vain for a thread of continuity, only to be disappointed and surprised as the papers shift abruptly from one topic to another. To cite only one example, in Part I is a chapter titled "Cost of Farm Programs" and another titled "Distribution of Benefits from Existing and Prospective Farm Programs," neither of which has much to do with the General and Social Characteristics of Rural Communities, although both are relevant to the larger theme of the book.

Some discontinuities and unevenness are probably inherent in books that report proceedings of conferences. But a careful editing could have alleviated the problem and added a cohesiveness and cumulativeness that would have made this a more effective, valuable volume.

The book makes an important departure from much of the agricultural economics literature in the attention it gives to rural people not on farms. But then the reader is disappointed to find practically no consideration given to the extent to which existing urban problems reflect the transference of a widely diffused rural social and economic problem to the urban centers, where it is concentrated and politically explosive. Nor is there any explicit recognition that had past policy approached the equity problem in a broader, rural-urban context, programs oriented to solving the rural relative-income problem might have avoided or at least attenuated our current urban problems.

The book is also deficient in its lack of rigorous theoretical analysis of some of the major issues. The reader sometimes has the impression that the overriding concern was in bringing data to bear on the problem, rather than in truly understanding the nature of the economic world that generated the problem. This reviewer, at least, would have felt a bit more comfortable with some of the data had he felt that they always showed what the authors thought they were showing. A more systematic exploration of some of the theoretical issues in early chapters would have been helpful in this regard. Similarly, the work could have focused more explicitly on externalities, a major subject in any serious discussion of the distribution of burdens and benefits from economic development. The tendency of the papers to approach the problem in a microframework causes an important share of the public policy issues to be slighted or ignored.

One chapter prepared by two sociologists and another by a political scientist are particularly insightful contributions. One wonders why social scientists other than agricultural economists were not drawn on to a greater extent, given the problem orientation of the volume. Political scientists might have something to say about why we obtained the kinds of economic policies we did and how more desirable policies might be obtained in the future.

These caveats aside, the book does make an important contribution to the literature. It makes important steps towards documenting a serious problem and sets the stage for additional analytical work. For those who think we are near adjustment in U. S. agriculture, even in the commercial sector, Heady's

chapter is particularly discouraging. He discusses the many adjustments that are yet to take place and some that might take place if government policy will allow them.

Selected chapters of the book will be useful additions to the reading list of policy courses that take a broad approach to public policy and in development courses, where the U. S. experience can be instructive as to what is likely to happen in developing countries. The lack of technical jargon in most of the articles makes the collection accessible to a wide group: the public policy worker, the layman, the undergraduate student, and the professional or near-professional. In fact, it may well be that the attempt to serve such a wide audience is the root of some of the volume's deficiencies.

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Kneese, Allen V., Robert U. Ayres, and Ralph C. d'Arge, *Economics and the Environment: A Materials Balance Approach*, Baltimore, The Johns Hopkins Press, 1970, x + 120 pp. ($2.50 paper)

According to the preface this brief book is intended to (1) acquaint the reader with the environmental quality program at Resources for the Future; (2) view pollution policy and research in an integrated fashion by treating air, water, and solid wastes problems simultaneously; (3) show that external costs are not isolated aberrations but are inherent in the activities of modern economies; and (4) develop a framework for identifying priority research topics.

Essentially the book consists of two main chapters: the second, devoted to a description of residuals from production and consumption, and the third, comprising a treatment of residuals, general equilibrium, and welfare. These are preceded by a brief (15-page) chapter entitled "Perspective" and are followed by a yet briefer (11-page) chapter entitled "Conclusions, Policy, Research." There is no index.

The first chapter discusses externalities and their pervasiveness and argues that the ability of the natural environment to receive and assimilate residuals is diminishing, and hence it is becoming an increasingly valuable natural resource. The central cause for failure by economists to view the issue properly is said to be that it has not been perceived as a "conservation of mass problem." After alluding to the usual assumptions for Pareto optimality, the two that are said to break down are: (1) that residuals are unpriced and hence ignored in the decision process and (2) the absence of property rights in the assimilative capacity of the environment. The main conclusions of the chapter, in addition to those mentioned above, are that isolated and ad hoc intervention in the form of taxes, although necessary, is not sufficient for "optimal control." Hence we are said to need improved measures of external costs and more systematic methods for projecting residuals emissions.

Chapter 2 describes the nature of residuals from both production and consumption activities in several broad categories of the economic system. The materials balance approach is discussed and many charts and tables give such information as residuals associated with energy conversion, residuals from materials processing and industrial production, and residuals associated with final consumption. Although the authors admit that some of the estimates are based on crude data, this chapter may be, paradoxically, the most valuable to economists. It is rather difficult reading at times and some discussions seem uncomfortably attenuated; yet this material is of direct relevance to those working on the economics of residuals management.

Chapter 3, "Residuals, General Equilibrium, and Welfare Economics," attempts to cast the problem of residuals management in a general equilibrium framework. It has appeared in its essentials elsewhere [1, 4]. Portions of this chapter will be slow going for those not inclined to take the authors at their word as they move through a mathematical formulation of the problem. There are several typographical errors and at least one place where the substitution of one equation into another required the changing of subscripts—an operation performed without justification or explanation. The reader should also be aware of one recent criticism of the model employed here [3]. Next the authors move on to a discussion of environmental standards and decentralized decision-making. They address the general question of whether decentralized decision-making coupled with environmental planning can, in the presence of pervasive externalities, yield an optimum social product. After making the usual multitude of assumptions they offer the following understatement: "It is very likely that costs of obtaining the requisite information would far exceed the gains from *exactly* achieving the Pareto conditions . . . at least in the near future" (p. 96). But, they add, if a government agency could but meet all of the assumptions of their model (perfect knowledge about all production *and* utility functions, for example) there is a set of taxes and subsidies which would then permit decentralized decision-making to be Pareto-optimal.

Since the book is in fact a "progress report" it is understandable that the final chapter (Conclusions, Policy, Research) is far too brief, while at the same time it contains too many calls for more funding from government agencies and the "great foundations." I was particularly disappointed here since the authors are well qualified to do more. In their opinion, economic theorists "have no more urgent task than to devise improved models for analysis of environmental pollution" and other social problems. Instead, they lament, governments are increasingly pre-

occupied with the very short run brought on by political and social crises. They ask, somewhat rhetorically, in the last sentences of the book: "Are we worrying about tactics when strategy is the most urgent consideration? Are we trying to fine-tune a system that is getting more and more grossly out of focus?" (p. 119). While fine-tuning may indeed be a problem it seems only fair to point out that while economists are engaged in ascertaining the exact nature of all utility and production functions, as well as other necessary information to devise Pareto-efficient taxes and subsidies (which Buchanan and Stubblebine have rather persuasively argued are impossible to find [2]), the public will have empowered the politicians to do something about pollution with not a moment's sleep lost about the unknowable degree to which "social efficiency" has been impaired. If this occurs economists may miss a chance to contribute in a positive sense—say, by good empirical work on opportunity costs of alternative control schemes.

Regarding the success of the book in terms of the authors' declared objectives, it can be said that they adequately presented the broad concepts of the environmental quality program at Resources for the Future. As for breaking out of the traditional approach to pollution policy and demonstrating the pervasiveness of such externalities, they were also successful. However, "successful" can be taken in two ways: If we mean that they have demonstrated something of inherent intellectual interest, they get high marks; but if we mean the provision of a framework useful for policy action in environmental quality, it becomes more difficult to judge success.

Perhaps the book's most significant contribution is in elucidating the extent of the myth of an *operational* set of taxes and subsidies that will evoke Pareto-optimal behavior out of decentralized decisionmakers (not that we would ever know when we had reached that desideratum). Also, some important research topics are identified. However, this aspect, with its "challenge to economic theory" discussed above, is disappointing, given the knowledge, experience, and brilliance of the authors; but it is adequate and gives some indication of the direction that residuals management research is likely to go in the near future.

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Labys, Walter C., and C. W. J. Granger, *Speculation, Hedging and Commodity Price Forecasts,* Lexington, Massachusetts, D. C. Heath and Company, 1970, xxiv + 320 pp. ($12.50)

The expressed purpose of this research monograph was "to apply—[a] battery of techniques [spectral analysis, stepwise regression procedures, and exponentially weighted moving averages] to the study of the important problems, both practical and theoretical, associated with cash and future commodity prices." The results of this effort are perhaps the main reason that students of commodity markets might be interested in the study. However, the authors seek to extend these results into a general model of commodity price fluctuations and to use the model in price forecasting, and this phase of their study deserves some attention as well.

An introductory chapter presents a brief survey of commodity futures markets, including location of U. S. markets, commodities traded, contract characteristics, volume of trading (with comparisons to total production of the commodity traded and amount tendered for delivery on the futures markets), and open commitments. Such a survey is no doubt useful for general orientation and to help decide which commodities to study. The chapter also contains a very brief account of the history of trade in commodities, leading up to the introduction of futures trading. Close students of futures markets have studied the early history to further understand the basic functions that markets perform. The present account seems too sketchy for that purpose, however, and indeed it may positively mislead, appearing to veer too far in the direction of the risk aversion explanation for hedging use of markets. The authors give a passing nod to other reasons for hedging, but nowhere in the book do these other reasons appear to color the authors' conception of what futures markets are or how they work.

In the absence of clear evidence to the contrary, one must assume that the authors have an adequate basic understanding of futures markets. At the same time, misunderstanding is certainly not uncommon. (A list of people who have apparently read everything Holbrook Working has written and have understood none of it, despite its clarity, is available on request.) It is with some uneasiness or even dismay, therefore, that one encounters (on page 22) an example of a perfect, i.e. profitless, hedge of the carrying charge variety. Though the authors acknowledge that they run the "risk of oversimplifying," and though they add the caveat that of course the transaction is not profitless since "the original price paid to the farmer contained a discount for storage

charges," the damage to our confidence seems to be well-nigh irreparable. The most devastating consequence is that we are led to suspect that the authors feel that the cash and futures markets are separate and distinct, that the cash market is the real one, and that futures markets are good markets only if they move in concert with the cash markets and provide "perfect" hedges. While this is quite possibly an unwarranted assumption or suspicion to apply here, the path to enlightenment on futures markets is strewn with the bodies (or minds) of seekers who have fallen into this sort of error.

Chapter 2 presents a brief but well-balanced discussion of spectral and cross-spectral analysis of time series and a very short discussion of the better-known method of stepwise regression. The reader who is not thoroughly conversant with spectral analysis would undoubtedly need to consult some of the references given. If any fault is found with the treatment, it might be that most readers (including the reviewer) might have benefited from a more detailed discussion of a few analyses taken from the present field of enquiry, and there might have been more consideration of the consequences to spectral analysis of the kind of anomalies, such as nonstationarities of various sorts, that might be present in commodity market data.

In Chapter 3 there is a discussion of the random walk model of price behavior and empirical testing by spectral analysis of single-price series for random price movements in cash and futures prices of a number of grains, oils, and oilmeals. In general there was close agreement with random walk, even in cash prices, although several weak seasonals and one or two marked seasonals were detected.

Chapter 4, "An Expectations Theory of Cash and Futures Prices," seems to embody a curious concept of what is meant by expectations. Thus we are told that the goal of the chapter is "to determine whether futures prices respond to changes in market expectations and, as such, anticipate cash prices." Apparently the authors mean by this that futures prices should lead cash prices and that the lead should be measurable by cross-spectral analysis of cash and futures prices in the same market. Such a lead would not be expected if one holds the view that cash and futures prices are jointly determined in what is essentially a single market; and indeed the empirical results show only vestigial suggestions of a lead, but a strong tendency to coherence or synchronous price movements.

So far we have seen that commodity prices exhibit a random walk; that is, the markets predict prices so well that the price *changes* are rendered unpredictable. This conclusion is quite unsatisfying, aside from its being a mere corroboration of an existing theory, in that it leaves open the question of whether the random changes that occur are due to real economic factors affecting the commodities traded or whether they are generated by interactions among the traders in the markets and hence inimical to social welfare. This is indeed a central question and perhaps one which must remain open and to be decided on the merits in each market. Chapters 5 and 6 are devoted to posing the problem and subjecting it to empirical scrutiny. Eleven commodities are examined for coherence of futures prices with demand factors, supply factors, speculation, hedging, and open interest. Finding quantified variables that accurately reflect demand, supply, hedging, or speculation is of course very difficult, and how well the authors have succeeded is perhaps best left to each reader to decide. This reviewer has serious doubts. It is concluded that demand and supply factors have rather less, and hedging and speculation rather more, to do with price fluctuations than has usually been supposed. The authors reached the curious conclusion that markets with high speculative indexes, which they then characterize as having *excess* speculation [italics supplied], show the nearest approach to random walk. One might argue that since they exhibit random walk, the speculation in these markets does not seem to be excessive, despite the high index.

Chapters 7, 8, and 9 are devoted to an attempt to explain and predict price fluctuations in commodity markets. The same variables are used as were developed in the previous chapters, but the emphasis on methods now shifts to stepwise regression. Several other methods, including the use of Box-Jenkins models, are considered or applied in varying depth. The variables are permitted to enter the stepwise analysis with a wide range of lags. Some fairly high correlations were obtained in the explanatory equations, but often the correlated variables are lagged endogenous variables or variables subject to the same underlying economic forces. For example, soybean oil futures were explained by a stepwise regression in which the first variable to enter was an "oils index" composed of prices of lard and cottonseed oil. Other variables added little to the explanation, so one may question how much is really explained. One of the main conclusions of this section was that a random walk is the best predictor of cash and futures prices.

The concluding chapter reiterates the major conclusions of individual chapters and seeks to place this work in broad perspective among studies of commodity markets. This reviewer would like to offer his own observations along these lines.

One is not persuaded by this example that the blanket application of a versatile statistical technique to data in a field (even one such as commodity markets where data is abundant) is a promising source of new insights. Perhaps the insights need to precede or accompany the analysis, and the analytical techniques may need to be tailored to the task at hand. Of 788 coherences counted in this study, 497 or 63 percent were .20 or less and 658 or 83 percent were .35 or less. Finding so many low numbers is mind-boggling to say the least. There were few or

perhaps no surprises, the low coherences occurring where one would expect them and the high coherences likewise being predictable. Of 380 coefficients of determination, counting all stages in stepwise regressions, 45 percent were .20 or less, and once again high and low values occurred where one would expect them. A slight tendency to seasonal pattern in wheat futures was detected and was rationalized in terms of Gray's findings, but without the previous study to reinforce them the indications from the spectral analysis might easily have been dismissed as insignificant.

Time series analysis is essentially and inevitably historical analysis. To the doctrinaire historian nothing is repeated and to the doctrinaire statistician if a series is not repetitive, that is, if it is not generated by a well-defined stochastic process, it is not capable of analysis. The economist or market analyst usually has to compromise the standards of both historian and statistician and probably has to invent his own methods of analysis. It seems less important to decide between a Parzen window and a hanning lag window than it is to consider whether one's method is equally appropriate to periods of inventory buildup and inventory depletion. The present work may err a bit on the side of excessive concern for statistical rather than economic virtue.

The book is attractively and clearly printed, with perhaps just a few more misspellings or typographical errors than one would desire. There is an excellent bibliography.

ARNOLD B. LARSON
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Meadows, Dennis L., *Dynamics of Commodity Production Cycles*, Cambridge, Massachusetts, Wright-Allen Press, Inc., 1970, xi, + 101 pp. ($14.75)

An interesting method of studying commodity cycles in their dynamic environment is provided in a rather concise setting. Basically, Forresters' "Industrial Dynamics" is applied to commodity cycles; thus, a general knowledge of Forrester's work and the associated simulation language is a prerequisite.

Meadows argues that while much effort has been devoted to the analysis of individual commodity cycles, underlying characteristics common to most commodities allow general applicability of a unique model. Shifts in production of a commodity are postulated to be the result of producer actions to maintain a desired level of inventory in relation to predicted consumption. Prior efforts to analyze commodity cycles, according to Meadows, have focused on price and output fluctuations instead of looking at the inherent stability (or lack of it) in the system as measured by the damping factor.

While the time-honored Cobweb model has attempted to establish the stability of the system, the static nature of the assumptions involved is deemed to render the cobweb analysis obsolete. A user of the cobweb model must assume that producers form their price expectations, determine their production level, and acquire control of production resources instantaneously.

The goal of the Dynamic Commodity Cycle Model (DCCM) is to schedule production so as to maintain a desired inventory level. It shifts from a point-to-point change to a "rate-of-change" form of analysis embodied in Industrial Dynamics and the DYNAMO simulation language. The rate-of-change concept essentially involves casting all relationships into differential equations. Effects of values of variables in past time periods are easily introduced as time delays in the production process, in forecasts of consumption and producer prices, and in capital accumulation. For example, several periods of consistent low or high retail prices may be needed before producers realize a change has occurred and decide to change their rate of production. Then, more time may be needed to accumulate investment capital or to reduce holdings of capital goods. Thus, many rigidities in production are accounted for in the model. Investment and biological time delays may result in several years' delay in production response.

The hog cycle is chosen to illustrate the DCCM in an empirical context. Brief mention is made of the adaptation of the model to the cattle and broiler cycles. Results of the hog cycle analyses are presented in sufficient detail to enable the reader to fully appreciate the empirical performance of the theoretical model. Finally, some determinants of the stability of the model are discussed.

Meadows' criticism of the dynamic deficiencies of the cobweb model are illustrated by a review of empirical applications from the late 1800's through the early 1960's. The termination of the review coincides with the date several other dynamic analyses were commenced—the time when the computer and simulation became of age. Thus we have no idea of his assessment of other empirical analyses of the dynamics of commodity cycles. While many of the more recent works do not use the rate-of-change concept, they do provide dynamic feedback loops. Also, several of the relationships assumed constant in the DCCM application enter these models as functionally determined endogenous variables.

I feel that the DCCM does not have overall applicability to all commodity analyses as claimed periodically throughout the book. While one can "force" the economic behavior of any commodity's production, distribution, and consumption into the DCCM framework, crucial behavioral attributes unique to the commodity could well be lost. However, I recommend serious study of this book by those involved in commodity research, as it presents a dynamic comprehensive systems approach which recognizes a gradual change in expectations and resulting behavior over time. The DCCM is a new model among many for designing future commodity analyses.

RICHARD J. CROM
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Preeg, Ernest H., *Traders and Diplomats: An Analysis of the Kennedy Round of Negotiations Under the General Agreement on Tariffs and Trade*, Washington, The Brookings Institution, 1970, xv + 320 pp. ($6.75)

In May 1967, with authority under the Trade Expansion Act of 1962 about to expire, the Sixth Round of GATT multilateral negotiations reached midnight agreement. The question of what the agreement meant is still obscure. The foreign-trade-policy establishment, which is monolithic on this issue, uses superlatives: the greatest ever, the most far-reaching reduction of barriers to trade, etc. Meanwhile American producers complain of injury from imports and lack of access to foreign markets. The ostensibly agreed governments clash angrily over subsequent trade-barrier acts or failures to act. And there is a great dearth of agreed information.

Hence this book is timely. It is billed, in Kermit Gordon's foreword, as a history of the negotiations, an analysis of the results, and a brief evaluation of their significance for future trade policy. Preeg, who participated in the negotiations, is a State Department officer; so that he has a career interest in stating the establishment superlatives. However, he also presents the facts, and the two are often sufficiently separated so that the reader can draw his own conclusions.

A chronological review, supplemented by separate chapters on agriculture and the five industry "sectors," brings the long confrontation alive again. Western Europe had started toward a free-trade economy protected against imports. The United States countered with these multilateral negotiations toward an open world economy. Beginning in May 1963, at least two years were lost wrangling over formulas and generalities: "linear," écretement, etc. The Common Market leaders held up the negotiations while they forced their internal integration. And the United States, as the book omits to note, had its fiasco of tariff "simplification." (A handful of technicians had obtained priority on funds and time for a professional exercise, which kept us from being prepared to negotiate specifics until 1965. It is a story still to be told.) And not only the United States and the EEC, but also the EFTA countries, Japan, the Commonwealth primary-product exporters (Canada, Australia, New Zealand, and South Africa), many less-developed countries, and others had to agree. Not only tariffs but also quotas, subsidies, and a variety of other barriers had to be covered. Meanwhile, some tariffs were raised, fought over, and retaliated against. Specific, detailed discussion of relevant facts began in 1965, so that when, with time run out, stubborn confrontation finally gave way to real effort to reach agreement, the materials needed to put together a responsible package deal were at hand.

The tariff part of the agreement is summarized and analyzed in some detail. Overall, the United States, EEC, United Kingdom, and Japan each lowered average nonagricultural duties slightly more than 35 percent. This represented about 5 percentage points on the value of the imported articles for the United States and the EEC; 7 points for the United Kingdom and Japan. Noting a number of ways of estimating the effect on world trade, Preeg gives "crude projections" indicating a 10 percent ($2–3 billion per year) expansion, assuming (a) tariff cuts fully reflected in import prices and (b) a minus-two price elasticity of demand for imports. But he undermines his main assumption by noting that the greatest tariff cuts were in the large-firm areas, not usually characterized by competitive pricing. (Incidentally, he gives no factual comparison with the earlier negotiating rounds.) In agriculture, although many individual tariffs were lowered, the more important support-program barriers remained a matter of bitter disagreement. Therefore, no projection of trade effect is given.

In matters of past policy, the book is almost straight State Department—the customary rewriting of history to glorify current policy. The linear (or across-the-board-percentage-cut) approach is asserted to have been new and decisive, although in fact it was proposed by the United States and debated internationally—with various counter formulas—in 1944 and 1945, and for the earlier negotiations was discarded in favor of a procedure for explaining exceptions from maximum cut item by item, substantially as was done in the Kennedy Round. The Kennedy Round is asserted to have played a vital role in relieving political tension in NATO, but the facts suggest the opposite: the negotiators in each major deadlock had to be ordered to reach agreement because their public bitterness was endangering political cooperation. Agriculture and nontariff barriers are asserted not to have been given major attention in the previous five rounds, yet the very opposite would be nearer the truth: the Commerce Department, about 1950, complained to the Trade Agreements Committee that U. S. negotiating power was being used to help our farm exports more than our factory exports; and the thrust of the early negotiations to *eliminate* all nontariff barriers caused many state-trading and other nontariff practices to be abandoned by our great trading partners.

On future trade policy Preeg says very little, and most of it is more consistent with his facts than with his policy assertions: The linear approach is unlikely, because it doesn't work in the areas where competition is keenest and protection is considered most effective, e.g., textiles; free trade might be negotiated within some less competitive industry sectors; greater leeway in negotiating authority is needed; nontariff barriers will take up much negotiating attention and require Congressional authorization; a "common law" of trade practices between East and West may be required; expansion of LDC exports is important; attention should be directed to the relation of trade to payments equilibrium and to other domestic policies affecting equilibrium rather than to

reciprocity; there is danger of a spiral of unilateral restrictions unless there is further mutual reduction of trade barriers.

This book is welcome because so little is available, but it almost completely misses the role of the Kennedy Round, and particularly its concept of reciprocal negotiation and balanced concessions, in helping governments evade their collective responsibility for specific common economic problems—product by product, sector by sector. Until this is grasped, future foreign trade policy will be ineffective. But if Preeg were to say it, the State Department would probably, in their Goldwynesque euphemism, "select him out."

ROBERT B. SCHWENGER
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Schultz, Theodore W., *Investment in Human Capital; The Role of Education and of Research*, New York, The Free Press, 1971, xii + 272 pp. ($8.75)

Professor Schultz is the Columbus of human capital; if he did not discover it, he rediscovered it. This book is the log of his voyage. It brings together in an edited form most of his main articles on the subject, together with some new material.

The core of Schultz' argument was presented in his 1960 AEA presidential address, reprinted in this volume. It is that the concept of human capital provides a unified explanation for a host of apparently disparate phenomena. First, it helps to explain the residual portion of economic growth not explained by growth in labor force and material capital; the puzzle of Germany's post-war recovery and the slow growth of the poorer nations are thus partially resolved. It explains why earnings rise more steeply with age for skilled people than for unskilled: the skilled are investing in general training during the early years. It also explains why the young migrate more than the old (because they have longer to reap the returns), and so on.

Even in the early 1960's, however, the concept of human capital was still under attack, and this book contains Schultz' replies to the criticisms of Schaffer and Wiseman. The fact that the concept is now accepted by almost all economists (except those who reject any concept of capital) is a measure of the success of Schultz' work. The last part of the book is thus able to draw heavily on the findings of the many scholars whose work in this field he has inspired.

This last part deals mainly with the rates of return to education and research (mainly agricultural) and with their implications for policy and further research; the earlier chapters are mainly concerned with Schultz' pioneering measurements of the U. S. stock of human capital, valued at cost. There is space here to comment on only a few of the issues that arise.

In Schultz' view (and the reviewer's) the key variable to measure from both the positive and normative point of view, is the cross-sectional rate of return to investment in different types of human capital. But from the normative angle the policy significance of the cross-sectional rate of return to, say, college education depends crucially on the elasticity of substitution between college graduates and others. The higher the elasticity the more useful the rate-of-return data become, because we can change relative supply a lot without the rate of return itself changing to mock us. Schultz surprisingly does not discuss this key issue at any length, but he presumably considers the elasticity is high. However, he does discuss at length the fact that the rate of return to graduation has not fallen, despite the increase in the relative number of graduates. This he attributes to an increase in the relative demand for graduates, for which many possible explanations are offered. But if the elasticity of substitution is high enough to make rates of return into useful policy guides, it may also be high enough to explain a good deal of the stability in the rates of return, without invoking shifts of demand. However, we still know very little about this elasticity and it is not a topic on which Schultz has worked.

In an interesting chapter on the "changing patterns of earnings foregone" he points to increasing labor force participation among students, particularly among graduate students, whose stipends should in his view be considered a payment for services rendered. Including these in net benefits would have the effect of raising the social and private rate of return to graduate education to double the figure of 7 percent (exclusive of stipends) calculated by Hanoch. If some allowance could be made for the value of research output (such as Hanoch's own thesis), the social return would presumably be still higher. At the other end of the scale, Schultz (and Fishlow, whom he quotes with approval) considers that the production lost from having children in school is likely to fall as a country gets richer. This seems questionable. Even in societies like ours, adjusted to child labor laws, the potential contribution of a child (in say retailing) is surely much more than in a poorer country (in domestic tasks or in meeting the peak demand for agricultural labor).

Schultz is mainly interested in the positive economics of his subject, but is also full of policy suggestions, mostly of the kind designed to help the market to work better. Thus, he favors full-cost pricing in universities, combined with proper loan schemes and subsidies for those whom society wishes to attend but who will not go unsubsidized. He does, however, recognize the importance of public expenditure on elementary and secondary schools as a way of redistributing income. He is skeptical of the feasibility of forecasting the future demand for places in higher education or for trained manpower and urges that institutions should concentrate their efforts on providing broadly-based and flexible courses. Again

he presumably assumes a high elasticity of substitution between types of educated manpower; otherwise one should favor some attempt to penetrate the fog of uncertainty surrounding the future. Policy-makers ought to think hard about their functions when reading his book but should not expect to find detailed help with specific problems.

For future research Schultz considers the main task is to achieve a yet more generalized capital theory, in which technical progress in machinery and in the mental furniture that education has to offer are seen as forms of capital formation alternative to the replication of existing physical and mental equipment and to the replication of the species. As Schultz presents it, this is an inspiring and challenging vision.

One final practical comment from the reader's angle: Consisting largely of reprints, the book is inevitably repetitious. Given this, it might have been easier to read if the reprints had been presented as such, with sources and dates. But this is a book that shows a really creative mind at work forging new ideas, which in many cases it has remained for his many followers to develop in more exact detail.

RICHARD LAYARD
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Torgerson, Randall E., *Producer Power at the Bargaining Table: A Case Study of the Legislative Life of S.109*, Columbia, University of Missouri Press, 1970, ix + 328 pp. ($9.00 cloth, $6.00 paper)

As its name implies, this book traces Senate Bill S.109 from its conception during the early 1960's through its signature into law by President Johnson on April 16, 1968. In the preface the author purports to treat three broad areas: (1) the issue of farm bargaining as viewed by various segments of agricultural industry; (2) the movement of S.109 through the arena of lobby group coalitions; and (3) the changing balance of farm power on Capitol Hill.

All three topics are thoroughly covered in the book. Three cases in Chapter 1 illustrate the resistance, harassment, and discrimination farmers faced in their attempts to bargain collectively with processors during the 1960's. Chapter 2 describes the original drafting of S.109 by the American Farm Bureau Federation. Chapter 3 traces the formation of a coalition among three farm organizations to promote the bill and some "bargaining" among the three groups over the content of the bill. The positions taken by various opponents and proponents of the bill at its first hearing in June 1966 are outlined in Chapter 4. Significant revisions of the original bill, a second subcommittee hearing, and reintroduction of S.109 in the 90th Congress are described in Chapter 5. Chapter 6 documents the attitudes of various industry groups toward the bill's 1967 version, and the entry of Agriculture Secretary Freeman into the controversy surrounding this proposed legislation.

A highlight of the bill's legislative journey, its support by all major farm organizations at the May 1967 Senate hearings, is described in Chapter 7. Chapter 8 traces the disintegration of this farm unity as the bill was amended to meet the objections of its opponents. Chapter 9 describes the inversion of the bill's original proponents and opponents, the attempts of farm interests to amend the bill back to its original form or to kill it, and the growing disagreement among farm organizations over the bill. In Chapter 10 the agreement on a compromise among farm organizations and amendments by original opponents on the House floor to make the final version "watered down" and "processor-oriented" are documented, along with its final passage and signature into law. Chapter 11 is devoted to the author's own interpretations of the meaning and significance of S.109.

The book is well written, thoroughly researched, and carefully documented. Although it is virtually devoid of economic analysis, its contents should be of interest to all students of agricultural policy. In particular, Chapters 2 and 11 provide the reader with considerable insight into the legislative process and the ability of farm groups to function effectively in today's political arena. Its light literary style qualifies the book as "leisure reading" for persons with even a cursory interest in farm policy and agricultural bargaining issues.

Since the first ten chapters contain the author's impressions of events as they actually occurred, little opportunity exists for interpretation by the reviewer. However, some of Torgerson's conclusions in Chapter 11 are open to question. The impact of S.109 on the agricultural bargaining environment and on future legislation remains to be seen. The reviewer's conversations with bargaining association representatives who have filed complaints under this legislation and with USDA administrators charged with implementing the bill's provisions suggest that S.109 is providing little more relief from discriminatory practices than was available before the bill was enacted. Such a result could have been predicted from Torgerson's interpretation of the bill. On the other hand, the passage of S.109 may have provided impetus for introduction of subsequent bargaining legislation, including the "Sisk bill" now pending before Congress.

Torgerson's conclusion that general farm organizations will assume much of the future responsibility for farm bargaining is questionable. Many commodity bargaining associations (particularly on the West Coast) have achieved a measure of success bargaining on behalf of their members. If these associations were certified as bargaining agents under proposed legislative provisions, general farm organizations may not significantly increase their activities in this area. Indeed, if the National Farmers Organization and the American Agricultural Marketing Association are classified as nationwide bargaining associations, one could argue that further entry of general farm

organizations as active participants in the bargaining arena is doubtful.

The conflicts between farm bargaining groups and operating cooperatives will probably continue to exist, despite the author's recommendation for a "cooperative systems approach to improving farm incomes" (p. 217). These conflicts are a result of differences in operational objectives of the managements of the two types of organizations. Some competition between bargaining associations and operating cooperatives may be desirable to keep each other "honest." Torgerson also argues that "a new mandate is probably needed to enable cooperatives to federate through regional and national federations to effect greater market power for farm operators" (p. 231). Results from other studies suggest that some limits should be placed on this power, to prevent its misuse against both farmers and consumers [1].

Notwithstanding these differences in interpretation, this book is strongly recommended to *AJAE* readers. It is deserving of the recognition it has already received, as noted in the May 1971 issue, page 392.

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[1] YOUDE, JAMES G., and PETER G. HELMBERGER, "Marketing Cooperatives in the U. S.: Membership policies, Market Power, and Antitrust Policy," *J. Farm Econ.* 48 (3, pt. 2): 23–36, Aug. 1966.

Tweeten, Luther G., *Foundations of Farm Policy*, Lincoln, The University of Nebraska Press, 1970, xi + 537 pp. ($9.50)

This is a superb book. Anyone who teaches or is a student of policy for commercial agriculture, rural development, or rural poverty will want to own a copy. There are few things more difficult to organize and write than a good book on policy. Professor Tweeten has done just that.

His volume is not a textbook. Only the first five descriptive and historical chapters could be handled by the typical undergraduate. All the rest require a good command of economic theory. Tweeten has produced a reference work, many parts of which could usefully be assigned in a graduate course.

Chapters 1 through 11 plus 15 (400 pages) are devoted to food and fiber industry policy and the nature of the public decision process in agriculture. The first five chapters include an extensive discussion of the role of values in the decision process, an historical overview of the rise and fall of farm organizations and of agrarian protest in the United States, as well as a brief economic history of the development of American agriculture and its institutions.

Chapter 6 analyzes the nature of the farm problem and is followed by three chapters describing the economic structure of agriculture's input supply and product markets. A short history of the last 40 years of agricultural commodity programs is presented in chapter 10, followed by a chapter that analyzes the alternatives and decisions faced in operating commodity programs. Finally, chapter 15 treats U. S. foreign trade and aid in agricultural products.

This is an extremely comprehensive and well-written treatment of commercial agricultural policy. It provides the most complete historical background to the issues of agricultural policy of any volume since Murray Benedict's more narrowly focused opus on the programs of the 1930's and 1940's. The author has made extensive use of statistical materials in both descriptive and analytical efforts. The approach tends to be highly positivistic. This keeps the injection of the author's values and judgment to a minimum and lets the reader draw most of his own conclusions. On occasion, however, it leaves the reader with an unsatisfying mass of data and analytics from which he may or may not be able to derive conclusions.

Tweeten has consciously avoided discussing most of the political dimensions of agricultural policy. This is a common, perhaps even sensible approach, but it does often introduce an aura of unreality, particularly to the evaluation of choices in commodity programs and to the PL 480 discussions in chapters 11 and 15. It also leads to some distortion of the apparent attractiveness of some alternatives. For example, at several points the author treats with approval the notion of commodity stocks as a strategic reserve. While defensible in the abstract, as a practical matter it has been used politically as little more than an excuse for another raid on the treasury. Similarly, I have reservations about the wisdom of the author's suggestion of creating an independent Agricultural Board (page 355) "once removed" from the political process (much as the Federal Reserve Board is) which would make many of the decisions in agricultural policy. In the end it would probably behave like all regulatory agencies, which have eventually been captured by the regulated industry.

The only major difficulty I had in the chapters on commercial agricultural policy was with the discussion of fixed resource (asset) theory, which I found confusing if not itself confused in spots. The graphic on page 172 with which the exposition of asset fixity begins is not adequate to the task. The opportunity cost (salvage value) of the agricultural industry as a whole sometimes seems confused with the opportunity cost for specific inputs. It is distracting, if not confusing, to have the notions of transfer cost and the various costs which he classifies under "endodermal hypotheses" separated from the idea of asset fixity. They really constitute part of the difference between acquisition and salvage values. In any case, the introductory discussion does not make it clear that for asset fixity to exist, both (1) acquisition price and salvage value must differ ($P_{x_{iA}} - P_{x_{is}} > 0$) and (2) imperfect knowledge must prevail.

Tweeten certainly starts out in the right direction on page 174 in discussing the effects of resource fixity on farm output and earnings, but I think he confuses the exposition by failing to make the distinction between (1) farm and nonfarm produced inputs and (2) those inputs that are specialized in agriculture and those not specialized. I think some of our difficulty in treating this phenomenon is that resource (asset) fixity is misnamed. It is more properly investment-disinvestment theory.

Professor Tweeten saves his best for the last. His chapters 12, 13, 14 (100 pages) on rural poverty are outstanding. No one should teach this subject in the next several years without recourse at least to chapter 12; it is a superb statement of the nature and causes of rural poverty integrated into a fine synthesis of rural development theory. He provides insights and a general perspective that constitute a solid intellectual contribution. This is again accompanied by a wealth of descriptive material that excludes only the health dimension of poverty and development. Another chapter reviews past poverty programs and a third evaluates priorities for prospective programs on a "cost effectiveness" basis. I have far less confidence in the accuracy of poverty statistics than the author does and I share his concern over the adequacy of definitions used. Tweeten is misled in his belief (page 364) that the Social Security Administration definition of poverty is conceptually different from the food-budget-based Orshansky definition. All the poverty numbers since about 1965 have been based on the "primitive" Orshansky definition. I believe that the difference he observes in the incidence of farm poverty (page 364) is primarily due to drastic reductions in the income adjustment for farm-produced food, which originally was set at the indefensible level of 40 percent of total farm income!

Even more impressive is his chapter (16) on public welfare and economic efficiency. This is an insightful summary of where we stand in welfare economics *placed in the context of public decision-making* and its necessity for valuation of alternatives. It is a sophisticated exposition of the dilemmas and traps that lie before an economist who would practice as a policy advisor. Professor Tweeten has made a fine contribution in this final chapter, as indeed he has with this entire volume.

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Books for listing in this section should be sent to the Book Review Editor (see inside front cover for address).

Books Received

Arnold, Adlai F., *Foundations of an Agricultural Policy in Paraguay*, New York, Praeger Publishers, xx + 294 pp. $17.50.

Blase, Melvin G., ed., *Institutions in Agricultural Development*, Ames, The Iowa State University Press, 1971, xii + 247 pp. $5.95.

Butterwick, Michael, and Edmund Neville-Rolfe, *Agricultural Marketing and the EEC*, London, Hutchinson Publishers, 1971, xii + 287 pp. £3.50.

Conklin, David W., *An Evaluation of the Soviet Profit Reforms; With Special Reference to Agri-Culture*, New York, Praeger Publishers, Inc., 1970, xiii + 192 pp. $15.00.

Diaz, Longinos Jimenez, *Analisis Economico de la Estructura de las Explotaciones Agrarias de la Comarca de la Armuna (Salamanca), (Economic Analysis of the Structure of Agricultural Exploitations in the Region of Armuna (in the State of Salamanca, Spain)*, Salamanca, 1970, 68 pp. Price unknown.

Edwards, A. M., and G. P. Wibberley, *An Agricultural Land Budget for Britain 1965–2000*, Ashford, Kent, Wye College (University of London), 1971, xii + 120 pp. 15s. Paper.

Ehrlich, Paul R., John P. Holdren, and Richard W. Holm, eds., *Man and the Ecosphere*, Readings from *Scientific American*, San Francisco, W. H. Freeman and Company, 1971, viii + 307 pp. $11.00 cloth $5.75 paper.

Environmental Action, *Earth Tool Kit*, New York, Pocket Books, 1971, viii + 369 pp. $1.25 paper.

Fundaburk, Emma Lila, *Reference Materials and Periodicals in Economics: An International List in Five Volumes: Vol. 1, Agriculture*, New Jersey, The Scarecrow Press Inc., 1971, xxi + 594 pp. $15.00.

Gill, Kartar Singh, *Wheat Market Behavior in Punjab & Haryana, 1968–69 to 1970–71*, Ludhiana, Punjab Agricultural University, 1971, 124 pp. Price unknown. Paper.

Grubbs, Donald H., *Cry From the Cotton*, Chapel Hill, The University of North Carolina Press, 1971, xvi + 218 pp. $8.50.

Halter, Albert N., and Gerald W. Dean, *Decisions Under Uncertainty; with Research Applications*, Cincinnati, South-Western Publishing Co., 1971, vi + 266 pp. Price unknown. Paper.

Hansen, Alvin H., *A Guide to Keynes*, New York, McGraw-Hill Book Company, Inc., 1953, xiii + 237 pp. $2.50 paper.

Heady, Earl O., ed., *Economic Models and Quantitative Methods for Decisions and Planning in Agriculture;* Proceedings of an East-West Seminar, Ames, Iowa State University Press, 1971, xiii + 518 pp. $10.50.

Heyer, Judith, Dunstan Ireri, and Jon Moris, *Rural Development in Kenya*, Nairobi, East African Publishing House, 1971, xiv + 132 pp. Price unknown. Paper.

Hickman, Edgar P., and James G. Hilton, *Probability and Statistical Analysis*, Scranton, Intext Educational Publishers, 1971, x + 366 pp. $9.00.

Hicks, George L., and Geoffrey McNicoll, *Trade and Growth in the Philippines; An Open Dual Economy*, Ithaca, Cornell University Press, 1971, xi + 244 pp. $8.50.

Hite, James C., and James M. Stepp, eds., *Coastal Zone Resource Management*, New York, Praeger Publishers, 1971, xxii + 169 pp. $13.50.

Howe, Charles W., and K. William Easter, *Interbasin Transfers of Water; Economic Issues and Impacts*, Baltimore, The Johns Hopkins Press for Resources for the Future, 1971, xiv + 196 pp. $9.50.

Intriligator, Michael D., *Mathematical Optimization and Economic Theory*, Englewood Cliffs,

Prentice-Hall, Inc., 1971, xix + 508 pp. $13.95.

Jackson, W. A. Douglas, ed., *Agrarian Policies and Problems in Communist and Non-Communist Countries,* Seattle, University of Washington Press, 1971, viii + 488 pp. $15.00.

Jha, B. V., *Agricultural Price-Stabilization in India,* Calcutta, Shot Publications, 1971, xv + 312 pp. Rs. 39, $7.50, £3.

Jones, Graham, *The Role of Science and Technology in Developing Countries,* New York, Oxford University Press, 1971, xiii + 174 pp. $5.75 cloth $2.50 paper.

Lockwood, Brian, *Samoan Village Economy,* New York, Oxford University Press, 1971, xiv + 232 pp. $10.75.

Love, Sam, ed., *Earth Tool Kit, A Field Manual for Citizen Activists,* New York, Simon & Schuster, Inc., 1971, 369 pp. $1.25 paper.

Marshall, Ray, and Lamond Godwin, eds., *Cooperatives and Rural Poverty in the South; Policy Studies in Employment and Welfare Number 7,* Baltimore, The Johns Hopkins Press, 1971, viii + 98 pp. $6.00 cloth $1.95 paper.

Mather, Loys L., ed., *Economics of Consumer Protection,* Danville, The Interstate Printers & Publishers, Inc., 1971, viii + 148 pp. $5.50.

Metzger, Gunter, *Die Genossenschaften in Peru und ihr Beitrag zur wirtschaftlichen und sozialen Entwickling des Landes: con Resumen en Espanol,* (Cooperatives in Peru and Their Influence on the Economic and Social Development of the Country; with Summary in Spanish), Marburg/Lahn, 1970, xviii + 186 pp. Price unknown.

Mohsenin, Nuri N., *Physical Properties of Plant and Animal Materials,* Vol. 1, New York, Gordon and Breach Science Publishers, Inc., xv + 734 pp. $24.50.

Resources for the Future, Inc., *Agricultural Development in the Mekong Basin,* Baltimore, The Johns Hopkins Press, 1971, 108 pp. $2.50 paper.

Schnitzer, Martin C., and James W. Nordyke, *Comparative Economic Systems,* Chicago, South-Western Publishing Co., 1971, vi + 650 pp. Price unknown.

Searle, S. R., *Linear Models,* New York, John Wiley & Sons, Inc., 1971, xxi + 532 pp. $19.95.

Serraino, William J., Surendra S. Singhvi and Robert M. Soldofsky, *Frontiers of Financial Management,* Cincinnati, South-Western Publishing Co., 1971, x + 462 pp. Price unknown. Paper.

Stockton, John R., and Charles T. Clark, *Introduction to Business & Economic Statistics; 4th Edition,* Chicago, South-Western Publishing Co., 1971, x + 770 pp. Price unknown.

Tewari, R. N., *Agricultural Development and Population Growth,* Delhi, India, Sulton Chand and Sons, 1970, viii + 126 pp. $5.00.

The Research Institute of Agricultural Economics, *Long-Term Projections of Supply, Demand and Trade for Selected Agricultural Products in Taiwan,* Taipei, National Taiwan University, 1970, xii + 262 pp. Price unknown. Paper.

Weitz, Raanan, ed., *Rural Development in a Changing World,* Cambridge, The MIT Press, 587 pp. $20.00.

Wollman, Nathaniel, and Gilbert W. Bonem, *The Outlook for Water,* Baltimore, The Johns Hopkins Press for Resources for the Future, 1971, xviii + 286 pp. $12.00.

Announcements

WINTER MEETING
AMERICAN AGRICULTURAL ECONOMICS ASSOCIATION WITH
ALLIED SOCIAL SCIENCE ASSOCIATIONS
December 27–30, 1971

Process Analysis and the Economics of Production

(Joint session with Econometric Society)

Chairman: FRED H. WEIGMANN, Louisiana State University

Process Analysis and the Neoclassical Theory of the Firm: NICHOLAS GEORGESCU-ROEGEN, Vanderbilt University

Alternative to the Neoclassical Theory of the Firm: GLENN L. JOHNSON, Michigan State University

Discussants: RICHARD R. NELSON, Yale University

J. E. FARIS, Virginia Polytechnic Institute and State University

The Theory of the Firm in a Nonmarket Environment

Chairman: WILLIAM D. TOUSSAINT, North Carolina State University

Economic Behavior in Public Sector Markets: The Food Stamp Case: KEITH BRYANT, University of Minnesota

The Theory of the Firm and the Management of Residuals: MAX R. LANGHAM, University of Florida

Discussants: ALLEN V. KNEESE, Resources for the Future

Mancur Olson, University of Maryland

Economic Growth and Rural Poverty

(Joint session with American Economics Association)

Chairman: T. T. WILLIAMS, Southern University (Baton Rouge)

Technical Change and the Distribution in Income in Rural Areas: CARL GOTSCH, Harvard University

The Poverty Programs of the 1960's: An Evaluation: EMIEL OWENS, University of Houston

Discussants: JOSEPH D. COFFEY, U.S. Department of Agriculture

J. MARTIN REDFERN, University of Arkansas

NOMINATING COMMITTEE, 1972–1973, AAEA OFFICERS

In accordance with Article VII of the constitution with the concurrence of the Executive Board, I hav appointed the following persons as members of committee to nominate persons to fill vacancies i offices of the Association for the year beginning Au gust 1972.

Jimmye S. Hillman (*chairman*), University of Ari zona

William Chromarty, Connell & Co.

Melvin L. Cotner, Natural Resource Economic Division, Economic Research Service, USDA

Emiel W. Owens, University of Houston

James S. Plaxico, Oklahoma State University

Wayne A. Schutjer, Agricultural Developmen Council, Inc. and Pennsylvania State Universit

Gary L. Seevers, Council of Economic Adviser and Oregon State University

Any member of the association is eligible and i invited to submit suggestions as to nominees to Jim mye S. Hillman as chairman or to other members o the committee. Dr. Hillman's address is Departmen of Agricultural Economics, University of Arizona Tucson, Arizona 85721.

VERNON W. RUTTAN
President

AAEA DISTINGUISHED EXTENSION PROGRAM AWARD

To encourage the development of excellence in Ex tension economics work, the American Agricultur Economics Association will offer one award of $25 in 1972. The award will be known as the Distin guished Extension Program Award. Nominations fo the award may be made by any member of th American Agricultural Economics Association an

selection will be made from among those nominated. An individual may be nominated or two or more individuals may be nominated jointly. It should be noted that the purpose of the award is to recognize an outstanding program achievement and not to recognize an individual or individuals for noteworthy service as Extension economists over an extended period of time.

Each nomination must be made by separate letter to the Extension Award Selection Committee by February 15, 1972, accompanied by four copies of documentary evidence of the achievement of the person or persons nominated. Documentary evidence of the achievement of the person or persons nominated should include an adequate presentation of the following points, in this order: (1) name(s) and title(s) of the person or persons nominated; (2) the problem about which the person or persons nominated built their Extension program and the objective(s) of the program; (3) clientele served; (4) the program developed to attain the objective(s), including analytical tools and techniques and education methods and procedures used; and (5) program accomplishments in terms of clientele response and/or establishment of the validity of an Extension technique. If two or more persons are nominated jointly, the specific contribution of each to the Extension program must be documented.

In order to be eligible for nomination, an individual or individuals must have had primary responsibility for the Extension program which supports the nomination. The program must have been active within one year of nomination, and its subject matter content must be principally in the field of economics.

Each nomination will be evaluated on the quality of the program that supports the nomination, using the documentary evidence submitted with the nomination as the sole basis for making this evaluation. Equal weight will be given each of the following five characteristics of the program:

1. Originality in selection of the problem and the application of economic principles, tools of analysis, and extension techniques to its solution.
2. Its effectiveness as a catalyst to other Extension economists in embarking on new programs or in applying new concepts to existing programs.
3. Its contribution to greater proficiency of Extension personnel in economics programs.
4. Its effectiveness in bringing about a significant change in behavior and/or understanding of the clientele.
5. Originality in recognizing educational opportunities which lend themselves to use in an Extension economics program.

Material should be sent to the subcommittee chairman, Gene McMurtry, Hutcheson Hall, Virginia Polytechnic Institute, Blacksburg, Virginia 24061.

AAEA EXTENSION PUBLICATION AWARD

To encourage and recognize excellence in Extension economics work, the American Agricultural Economics Association will offer an award of $250 in 1972. This award will be known as the Extension Publication Award.

Eligibility for the Award

This award is open to any professional agricultural economist; however, the nomination must be made by a member of the American Agricultural Economics Association. Any type of published material shall be eligible for the award.

Nominations for the Award

Each nomination for the Extension Publication Award must be signed by the nominator and include

1. the name or names of persons nominated;
2. a concise statement of the problem about which the publication is written;
3. a statement revealing the direct applicability of the publication to an ongoing Extension program;
4. identification of the audience for whom the publication was intended;
5. copies of the publication.

Criteria for Judging Nominations

1. Clarity of the problem statement about which the publication is written.
2. Completeness and conciseness of the analysis in the publication.
3. Adaptability of the publication to the audience for whom it was intended.
4. Contribution to the body of knowledge available for direct use in Extension economics programs.
5. Relevance to a current problem.
6. Timeliness and effectiveness in its intended purpose.

Eight copies of the nomination and supporting materials must be in the hands of the chairman of the selection committee by February 15, 1972. Nominations should be sent to Gene McMurtry, Hutcheson Hall, Virginia Polytechnic Institute, Blacksburg, Virginia 24061.

AAEA DISTINGUISHED UNDERGRADUTE TEACHING AWARDS

To recognize and encourage meritorious performance in undergraduate teaching in agricultural economics, two awards, each of $250, are provided for presentation by the American Agricultural Economics Association upon recommendation of the selection committee. Nominations for these awards may be made by an individual, a group of colleagues, or a department by the submission of supporting materials according to the rules for this program. Renominations are invited if the materials are brought up to date and resubmitted.

Eligibility for Nomination

Each nominee must

1. be actively engaged in teaching at a professional level during the school year in which the nomination is filed with the selection committee;
2. have demonstrated outstanding ability as an undergraduate teacher of agricultural economics.

Basis of Selection

Each award will be made on the basis of

1. the nominee's ability to motivate and stimulate students;
2. the impression he has made upon his students by the mastery of his subject, his technique, his vision, and his attitudes;
3. evidence of his interest in the improvement of teaching through publication and participation in professonal meetings directed toward improved teaching;
4. contribution to undergraduate education outside of the classroom through counseling, student placement, advice to the departmental student club, and similar activities;
5. service to the undergraduate program of the educational institution through extracurricular activities other than those included above, such as membership on college committees, teaching improvement efforts, and faculty leadership roles.

Materials to be Supplied by the Nominator

Six copies of the standard nominating form (supplied by the committee chairman) and required supporting materials.

Nominations

1. A nomination with supporting materials may be submitted by any individual, a group of colleagues, or a department. The committee chairman will provide the standard nominating form to department heads and chairmen. Others wishing to nominate may obtain forms from the committee chairman.
2. The selection committee for the Teacher Awards consists of six persons, either present or former undergraduate teachers, appointed for staggered terms, and will not include anyone nominated for the award. All members of the selection committee participate in the judging. The selection committee is empowered to recommend that no award be made if in their judgment none of the nominees is worthy of the award.
3. A nomination will be considered in either of two categories. The first category will include nominees who at the time of nomination have been engaged in undergraduate teaching for less than 10 years. The second category will include nominees who at the time of nomination have been engaged in undergraduate teaching for 10 or more years.
4. *Nominations with supporting materials for the Teacher Awards should be sent by February 15, 1972, directly to the chairman of this subcommittee,* John W. Malone, Jr., Chairman, Division of Agricultural and Resource Economics, University of Nevada-Reno, Reno, Nevada 89507.

AAEA AWARDS FOR RESEARCH IN AGRICULTURAL ECONOMICS

To recognize and encourage meritorious research in agricultural economics, 10 awards will be offered in 1972 by the American Agricultural Economics Association. Seven awards will be $250 each and three $100 each.

Selection for the awards will be made from published research, doctoral theses, master's theses, and articles in the *American Journal of Agricultural Economics* under the procedures outlined below. No one may receive more than one award in any one year, nor an award in the same category more than once every three years. No publication shall be eligible for an award if its substantive equivalent has received an award in any category in an earlier year. All materials submitted should be in English or accompanied by an English translation.

Awards for Published Research

1. Three $250 awards are offered for outstanding research publications in agricultural economics. These may include bulletins, articles, pamphlets, and monographs, but not textbooks. Joint authors of a winning report will receive proportionate shares of an award so far as eligible.
2. Submissions are invited from areas such as farm management, marketing, prices, cooperation, finance, policy, theory, methodology, rural development, farm population, foreign agriculture, land and water economics, conservation, regional adjustment, international trade, economic history, and state and local government, that throw significant light on the agricultural economy. Entries will be judged as a group rather than in particular areas.
3. Selections will be made from published research bearing a publication date in 1971.
4. Eligible recipients must be under 41 years of age at the time of publication but may have older joint authors.
5. Any paper authored or coauthored by a member of this awards subcommittee will be ineligible.
6. No penaly for joint authorship will be imposed unless one or more authors are over 41 years of age.
7. Each published report may receive only one award presented by the American Agricultural Economics Association in 1972. However a report may be entered in more than one of the following categories: (a) Outstanding article in the *American Journal of Agricultural Economics;* (b) Published research; (c) Doctoral thesis; and (d) Master's thesis.
8. Thirteen copies of each publication should be submitted for consideration, unless expense to the individual is excessive.
9. The awards subcommittee for published research consists of 12 persons, in addition to the chairman,

representing various fields. The members of the subcommittee will serve as voting judges, except the chairman, who will vote only in the event of a tie. The chairman of this subcommittee is J. O. Gerald, MED, ERS, U.S. Department of Agriculture, Washington, D.C. 20250.

10. *Publications should be sent directly to the chairman of this subcommittee before February 15, 1972.*

Awards for Doctoral Theses

1. Three $250 awards will be available for theses prepared by candidates for the doctoral degree in any department engaged in training agricultural economists at the doctoral level.

2. An entry must be submitted by the head of the department where the thesis was presented in partial fulfillment of requirements for a degree. A department may submit one thesis for each twelve doctoral theses or fraction thereof presented, in agricultural economics, to a graduate school faculty in the year. In determining the number of eligible theses, departments should limit consideration to theses of candidates who will receive a degree in agricultural economics and to theses of candidates who have taken agricultural economics as a field of emphasis.

3. Selection will be made from theses approved in final form by the student's advisory committee during the calendar year 1971, provided the candidate has met all other formal requirements for the doctoral degree.

4. A published thesis may be entered in both the published research and thesis classes but will be eligible for only one award. Although a published thesis is acceptable, a copy of the thesis as submitted to the graduate faculty should be sent whenever possible.

5. Three copies of a thesis must be sent to the subcommittee chairman. All copies will be returned after they have been read by the judges.

6. The awards subcommittee for doctoral theses will consist of 12 persons, in addition to the chairman. All members of the subcommittee will serve as voting judges, except the chairman who will vote only in the event of a tie. The chairman of this subcommittee is Joseph C. Purcell, Department of Agricultural Economics, Georgia Agricultural Experiment Station, Experiment, Georgia 30212.

7. *Theses should be sent directly to the chairman of this subcommittee before February 15, 1972.*

Awards for Master's Theses

1. Three $100 awards will be available for theses prepared by candidates for the master's degree in any department engaged in training agricultural economists at the master's degree level.

2. An entry must be submitted by the head of the department where the thesis was submitted in partial fullfillment of requirements for a degree. A department may submit one thesis for each fifteen master's theses or fraction thereof presented to a graduate school faculty in the year. In determining the number of eligible theses, departments should limit consideration to theses of candidates who will receive a degree in agricultural economics and to theses of candidates who have taken agricultural economics as a field of emphasis. Departments are strongly encouraged to submit either ribbon copies, in the case of typewritten theses, or Xerox or other processed copies of comparable quality.

3. Selection will be made from theses approved in final form by the student's advisory committee during the calendar year 1971, provided the candidate has met all other formal requirements for the master's degree.

4. Three copies of a thesis must be sent to the subcommittee chairman. All copies will be returned after the committee has completed its work.

5. A published thesis may be entered in both the published research and thesis classes but will be eligible for only one award. Although a published thesis is acceptable, a copy of the thesis as submitted to the graduate faculty should be sent whenever possible.

6. The awards subcommittee for master's theses will consist of eight persons in addition to the chairman. All members of this subcommittee will serve as voting judges, except the chairman who will vote only in the event of a tie. The chairman of this subcommittee is Robert W. Herdt, Department of Agricultural Economics, University of Illinois, Urbana, Illinois 61801.

7. *Theses should be sent directly to the chairman of this subcommittee before February 15, 1972.*

Award for Outstanding Article in the *American Journal of Agricultural Economics*

As has been the practice for a number of years, the editorial staff and the editorial council of the *American Journal of Agricultural Economics,* with the editor as chairman, will choose the most outstanding article published in the Journal during the preceding calendar year (in this instance 1971). The amount of this award is $250.

Announcements of the 1971 awards will be made at the 1972 annual meeting of the American Agricultural Economics Association. Names of the recipients of the 1971 awards appear in the 1971 proceedings issue of the *American Journal of Agricultural Economics.*

WATER RESOURCES RESEARCH

The Office of Water Resources Research is now accepting research proposals for consideration for fiscal year 1973 support, beginning July 1, 1972, pursuant to Title II of the Water Resources Research Act of 1964. Proposals must be submitted to the Office of Water Resources Research by January 10, 1972, in order to be eligible for fiscal year 1973 funding. Although proposals may be submitted to

OWRR at any time, those received after January 10, 1972 will be held for future consideration.

Detailed instructions and forms for the submission of proposals may be obtained from the Director, Office of Water Resources Research, U. S. Department of the Interior, Washington, D.C. 20240.

SUMMER INSTITUTE ON PROPERTY

A conference of leading lawyers and economists interested in theoretical, research, and policy aspects of property was held in Vail, Colorado, July 25-31. The conference consisted of general and small group sessions dealing with the structure of the property system, processes of change in property as an institution, procedures for transferring rights, and values and pricing of property. Emphasis was on real property, particularly land. Mini-papers and statements were prepared by all participants. Three major papers were presented by Roland McKean: "Property Rights, Appropriability, and Externalities in Government"; Allison Dunham: "Separation of Ownership from Decisions about Usefulness"; and Warren Samuels: "Welfare Economics, Power, and Property."

The conference was sponsored by the Interregional Resource Economics Committee, the Farm Foundation, and John C. Lincoln Institute. Papers will be published. For information write to Gene Wunderlich, Economic Research Service, U. S. Department of Agriculture, Washington, D.C. 20250.

AUTOMATION OF CAB SERVICES

The Commonwealth Agricultural Bureaux, which produce *World Agricultural Economics and Rural Sociology Abstracts* and some 19 other abstract journals covering different aspects of world literature on agriculture, are introducing computer techniques. These will further improve the provision of specialist scientific information services for agricultural research workers. The new system will facilitate:

(a) speedier journal production and earlier notice of papers;
(b) the inclusion of indexes in each issue of all journals;
(c) the search of the whole CAB data base to provide special outputs on selected topics, current awareness, personal and group services, annotated bibliographies, etc.;
(d) the interchange of information with other major information services in this field;
(e) the supply of magnetic tapes.

Some automated journal production will start in 1972 and further details will be announced in due course.

Any enquiries should be addressed to:

Systems Manager
Commonwealth Agricultural Bureaux
Farnham House, Farnham Royal
SLOUGH SL2 3BN, England.

BACK ISSUES NEEDED

The Secretary-Treasurer of the AAEA is authorized until January 1, 1972 to pay $1.00 each for any of the issues of the *AJAE* (formerly *JFE*) listed below. Other issues will be accepted only on a gratuitous basis, but the AAEA will pay the shipping cost:

Year	*Volume*	*Issues*
1919	1	1, 2, 3, 4
1920	2	1, 2, 3, 4
1921	3	1, 2, 3, 4
1922	4	1, 2, 3, 4
1923	5	1, 2, 3, 4
1924	6	1, 2, 3
1925	7	1, 2, 3, 4
1926	8	1, 2, 3, 4
1927	9	3
1928	10	4, Handbook
1935	17	1
1940	22	1
1941	23	1
1942	24	2
1943	25	1, 2, 3, 4
1944	26	2, 3, 4
1945	27	1, 2, 3, 4
1946	28	1, 2, 3, 4
1947	29	1, 2, 3, 4-1, 4-2
1948	30	1, 2
1950	32	1
1951	33	1, 2, 3
1952	34	1, 5
1953	35	1, 5
1954	36	1, 2, 3, 4
1958	40	1, 2, 3
1959	41	3
1961	43	1
1970	52	1

Journals should be sent prepaid to John C. Redman, Secretary-Treasurer, AAEA, Department of Agricultural Economics, University of Kentucky, Lexington, Kentucky 40506.

News Notes

UNIVERSITY OF CALIFORNIA, BERKELEY

APPOINTMENT: **E. Phillip LeVeen,** Ph.D. candidate, Chicago, acting assistant professor.

RETIREMENT: **George L. Mehren,** to be an officer of Associated Milk Producers, Inc., San Antonio, Texas.

CORNELL UNIVERSITY

APPOINTMENT: **James Jacobs,** Ph.D. Iowa State, research associate.

LEAVES: **Wendell G. Earle,** sabbatical, to do research and writing at Ithaca, one year; **George L. Casler,** teaching and research at Oregon State, one year; **Donald K. Freebairn,** sabbatical, Latin American Studies Center, Cambridge University, one year.

ECONOMIC RESEARCH SERVICE, USDA

(EDD is Economic Development Division; ESAD is Economic and Statistical Analysis Division; FPAD is Farm Production and Economics Division; FRAD is Foreign Regional Analysis Division; MED is Marketing Economics Division; NRED is Natural Resource Economics Division.)

APPOINTMENTS: **Bruce Burnham** and **Howard A. Osborn,** NRED; **Thomas A. Carlin,** FPED; **Anthony Gallo, Dale Heine,** and **Ray Sassani,** ESAD; **John E. Link,** FRAD; **Ken Nelson** and **Gary Perkins,** MED; **Rudie W. Slaughter, Jr.,** acting chief, Production Adjustment Branch, FPED; **Gaylord E. Worden,** chief, Agricultural Finance Branch, FPED.

TRANSFERS: **William Askew,** ESAD, to Agricultural Stabilization and Conservation Service; **Ray F. Brokken,** FPED, from Washington, D.C., to Corvallis, Oregon; **Lawrence Gambrell,** from Statistical Reporting Service to ESAD; **Karl Gertel,** NRED, from Hawaii to Washington, D.C.; **Herbert R. Hinman,** FPED, from New York to Washington, D.C.; **James E. Keefer,** FRAD, to Export Marketing Service, Washington, D.C.; **Richard S. Magleby,** FRAD, to USAID, Paraguay; **Walter Miller,** FRAD, to EDD; **James J. Naive,** FRAD, to ESAD; **Calvin L. Quance,** FPED, Oklahoma, to NRED, Washington, D.C.; **Leroy Quance,** FPED to NRED, Stillwater, Oklahoma; **David M. Schoonover,** FRAD, to Michigan State University; **Lawrence D. Schnake,** MED, to Manhattan, Kansas.

RESIGNATIONS: **Louis V. Dixon,** FRAD; **Jerry Gunnelson** and **Terry Roe,** MED.

HONORS: **Malcolm Clough,** ESAD, USDA's Superior Service Award.

MICHIGAN STATE UNIVERSITY

APPOINTMENTS: **James Booth,** Ph.D. Iowa State, and **William Haley,** Ph.D. North Carolina State, assistant professors.

LEAVES AND SPECIAL ASSIGNMENTS: **Myron Kelsey,** to Farm Credit Administration, Washington, D.C., one year; **G. E. Rossmiller,** to Korea to lead AID-Michigan State project to develop simulation model of agricultural sector; **Daniel Sturt,** to U.S. Department of Labor, second year; **Lawrence W. Witt,** USAID, Washington, D.C., leave extended to March 1962.

UNIVERSITY OF MINNESOTA

APPOINTMENTS: **Jerome W. Hammond,** Party Chief, Minnesota-Tunisia project under AID-University of Minnesota contract; **Pascal J. Wick,** Ph.D. Pennsylvania State, research associate on two-year assignment with Minnesota-Tunisia project.

LEAVES: **Harald R. Jensen,** to Agricultural Economics and Sector Planning Division, Office of Agriculture and Fisheries, Bureau of Technical Assistance, USAID, Washington, D.C., 1971–1972; **Malcolm J. Purvis,** returned from three-year assignment (one year as Party Chief) with the Minnesota-Tunisia project; **Delane E. Welsch,** under a joint University of Minnesota-Ford Foundation grant, stationed at Bangkok, Thailand, will spend 1971–1972 in the Department of Agricultural and Applied Economics, University of Minnesota.

RESIGNATION: **Jerome M. Stam,** to devote full time with Economic Development Division, Economic Research Service, USDA, Washington, D.C.

OHIO STATE UNIVERSITY

APPOINTMENTS: **Dennis Henderson,** Ph.D. Michigan State, and **Richard Duvick,** formerly with Economic Research Service, USDA, assistant professors.

OREGON STATE UNIVERSITY

APPOINTMENTS: **Lee Kolmer,** director of Cooperative Extension Service; **Jean Wyckoff,** professor, with administrative responsibility for extension economics program; **Dennis Fisher,** assistant professor; **Maurice Kelso,** visiting professor, Fall Quarter 1971; **Robert Schneidau,** Purdue, visiting professor, one year.

LEAVES: **Gary Seevers,** one-year extension of leave with President's Council of Economic Advisers; **Frederick Smith,** sabbatical, University of Rhode Island, 1971–1972; **James Youde,** University of California, Davis, 1971–1972.

STATISTICAL REPORTING SERVICE, USDA

RETIREMENTS: **Francis J. Graham,** statistician-in-charge of Minnesota State Statistical office, St. Paul; **David O. Mesick,** agricultural statistician, Minnesota State Statistical office, St. Paul; **Glenn D. Simpson,** deputy administrator and chairman of Crop Reporting Board, Washington, D.C.

WASHINGTON STATE UNIVERSITY

APPOINTMENTS: **A. H. Harrington,** acting department chairman, replacing **James Nielson,** now director of research in the College of Agriculture; **Milton Holloway,** USDA collaborator with National Resources Division, Economic Research Service.

UNIVERSITY OF WISCONSIN

APPOINTMENT: **William C. Thiesenhusen,** director of Land Tenure Center.

LEAVE: **John D. Strasma,** one-year extension of leave with Ford Foundation in Latin America.

OTHER APPOINTMENTS

John Abaelu, senior lecturer, University of Ife.

Aretas O. Bayley, M.S. Wisconsin, credit department, International Harvester Corporation.

Leonard L. Bull, Ph.D. Wisconsin, project leader, SE Wisconsin River Basin, Economic Research Service, USDA, at East Lansing.

Jesus Cutie-Tula, M.S. Wisconsin, teaching position in agricultural economics, University of El Salvador.

Fred O. Dako, M.S. Wisconsin, agricultural economist, Development Coordination Unit, Ministry of Agriculture, Ghana.

Ali K. El-Hassan, M.S. Wisconsin, senior marketing officer, Ministry of Commerce and Supply, Khartoum, Sudan.

Jose Maria Franco, Ph.D. Wisconsin, faculty of Catholic University Andres Bello, Caracas, Venezuela.

Frank Goode, formerly at Tennessee, staff of Pennsylvania State University, in rural development.

John R. Gordon, Ph.D. Wisconsin, assistant professor, Purdue University.

David A. G. Green, Ph.D. Michigan State, lecturer, Agricultural Economics University, College of Wales, Cardiganshire, Wales.

Jay M. Hughes, on leave from Minnesota's College of Forestry, director of the resources program, Cooperative State Research Service, USDA, to be responsible for coordinating and reviewing federal formula and grant research at state experiment stations and associated schools of forestry and at other designated schools of forestry.

Mario Kaminsky, Ph.D. Wisconsin, associate director of graduate programs in agricultural economics, Escuela Para Graduados en Ciencias Agro Pecuarias, Buenos Aires.

Waldon Kerns, Ph.D. Pennsylvania State, faculty of University of Georgia, in resource economics.

Ho Tak Kim, Ph.D. Pennsylvania State, staff of Seoul National University, in agricultural marketing.

Emmanuel O. Oyinlola, research associate, Iowa State University.

Carlos H. Paredes, M.S. Wisconsin, economist, Agrarian Reform Section, Banco Central del Equador, Quito.

Winston Phillips, Ph.D. Pennsylvania State, professor of economics, University of Guyana.

Carlos A. Quiros, Ph.D. Wisconsin, PROMECA, Central American Program for Promotion of Exports, CIECA, Guatemala.

James Ruane, Ph.D. Pennsylvania State, economics staff of Deere & Co., Moline, Illinois.

Rainer Schickele, formerly associate, Agricultural Development Council, and visiting professor, University of Ceylon; visiting professor, Michigan State University, winter and spring 1971; visiting professor, University of Minnesota, winter and spring 1972.

Jorge F. Schuster, Ph.D. Wisconsin, United Nations Commission for Latin America, Mexico City.

Cesar F. Vergelin, Ph.D. Wisconsin, assistant to Coordinator of Agricultural Development, Ministry of Agriculture, Buenos Aires.

OTHER RETIREMENTS

Mabel L. Hartley, assistant agricultural economist, University of Nevada, after 36 years of service with the Division of Agricultural and Resource Economics.

OBITUARIES

Ralph Cole, 71, professor of agricultural economics at the University of Nebraska, died in June 1971 in Lincoln, Nebraska. Born in Oxford, Nebraska,

Mr. Cole began his career in agriculture as an instructor in agricultural economics at the University of Nebraska in 1926. In 1934 he became an administrator of the national corn-hog program at Cornell University. From 1935 until 1948, with time out for military service, he was with the Farm Credit Administration in Washington, D.C., first as an appraisal analyst and then as chief appraisal standard secretary.

During his military career, Cole served from 1943 to 1946 as an officer in the military government division of the army. In 1945 he was a member of General Dwight D. Eisenhower's staff on food and agriculture in France and Germany. Returning to the midwest, he worked in Ft. Dodge until 1950 and farmed in Holdrege until 1962 when he rejoined the University of Nebraska as technical leader for a foreign student training project. He retired in 1966.

James Maddison Tinley, 73, an internationally known expert in agricultural economics, died in August 1971 in Walnut Creek, California. A native of South Africa, Dr. Tinley served his own country and the United States (his adopted land), as well as the United Nations, several African nations, Ireland, and Yugoslavia in a memorable 50-year career in government and education. At age 18 he fought for South Africa and later served in the U. S. Army during World War II.

Dr. Tinley earned his bachelor's degree with distinction from Pretoria University and his doctorate from the University of Minnesota. After joining the University of California at Berkeley in 1930, he became a prominent dairy marketing economist and was instrumental in developing procedures and techniques for the state's milk price regulations. He went to the Davis campus in 1950 and was a prime mover in setting up the International Agricultural Development program there. Over the years he had a number of leaves to advise foreign governments and to teach. He was an economic adviser in Ireland for the Food and Agricultural Organization of the United Nations and served the UN in Tanganyika. He also served the governments of Nigeria, Yugoslavia, and Kenya; and he stressed foreign agriculture and agricultural policy in his latest active years. After his retirement from the University of California in 1965, Dr. Tinley went to the University of Ibadan in Nigeria on a Ford Foundation grant, heading the agricultural economics department for two years.

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(Signed) John C. Redman
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D. Howard Doane
Pioneer in Farm Management Education
Founder, Doane Agriculture Service
Former President, American Society of Farm Managers
Vice-President, AFEA, 1945
Former Member, Agricultural Task Force, Hoover Commission

D. Howard Doane is a pioneer. Like a true pioneer, having achieved initial success he did not rest on his laurels but quickly set out on new exploration. Most of his pioneering not only has been related to agricultural economics but has contributed step by step to the evolution of that applied discipline.

Even D. Howard Doane's first years conformed to a pioneer's odyssey as he moved as a child from his native New York state, where he was born in 1883, to Nebraska and Missouri. As a college student he showed the ingenuity that came to mark his career. *Fortune* magazine of March 1951 recounts as follows:

> A freshman in the Missouri College of Agriculture, he stumbled across an article on farm management . . . which so inspired him that he wrote the author, Dr. W. J. Spillman of the U.S. Department of Agriculture, and asked for a job, without pay, during his summer vacation. As a result, young Doane made the first farm-management field study in the U.S. . . .

Soon after his graduation D. Howard Doane established at Missouri the first department of farm management in any U.S. agricultural college. In 1909 he set up a farm management demonstration farm, sometimes said to be a forerunner of farm management extension programs in farm planning. He was Missouri's first state leader of county agents. The AAEA records D. Howard Doane as among "those who pioneered in farm economics in the first decade of the present century."

His next pioneering venture was commercial farm management. After three years of private employment he organized in 1919 the first professional farm management and appraisal firm, now known as the Doane Agricultural Service. The new organization became known quickly not only for its technical competencies but for its high ethical standards. Objectivity in technical counseling was mandated from the beginning.

Keeping in touch with professional colleagues, he helped organize the American Society of Farm Managers in 1929 and served as president from that year until 1938.

In 1945 he was elected vice-president of the American Farm Economic Association.

In ensuing years he served on various commissions, including the Agricultural Task Force of the Hoover Commission. Then in 1967 he pioneered once more, moving to the School of the Ozarks where he developed a curriculum in agricultural business and after a half-century interval taught farm management to students from the surrounding area of southwest Missouri.

Don Paarlberg
Director of Agricultural Economics, U.S. Department of Agriculture
Former Assistant Secretary of Agriculture
Former Special Assistant to President Eisenhower
Former Coordinator, Food for Peace Program
Author, American Farm Policy, *1964;* Great Myths of Economics, *1968; co-author,* Food, *1944*

Don Paarlberg's career is marked by dedication to human understanding. As an outstanding teacher, lecturer, and sympathetic friend of American agriculture, he believes that knowledge is the right of all men. His counsel is sought by many because they know that he combines experience as farmer, teacher, researcher, and government servant with an inquisitive and analytical mind to isolate the essential aspects of complex economic and social problems of our day.

Don Paarlberg was born June 20, 1911, in Oak Glen, Illinois. He moved to Indiana with his family at an early age. After he was graduated from high school, he farmed for eight years. He then completed his B.S. degree at Purdue University and received his M.S. and, in 1946, his Ph.D. from Cornell University. He returned to Purdue to join the agricultural economics staff where he distinguished himself as teacher and researcher. In 1953 he was called upon to serve as Economic Advisor to Secretary of Agriculture Ezra Taft Benson. He was appointed Assistant Secretary of Agriculture in 1957, and in 1958 he was named Special Assistant to President Dwight D. Eisenhower. He was instrumental in formulating the Food for Peace Program and was named its coordinator. Other assignments included four years as Secretary of the National Agricultural Advisory Commission, two years as a member of the President's Committee on Foreign Economic Policy, and three years as a member of the President's Advisory Committee on Economic Growth and Stability.

Upon his return to Purdue in 1961 Dr. Paarlberg was named Distinguished Professor and quickly developed a reputation as a truly great teacher. His contributions as teacher were recognized through awards such as the Sigma Delta Chi Award for the Best of Purdue's Good Teachers (1961), the D. Howard Doane Award (1966), the Federal Land Bank Commemorative Medal for Outstanding Service to Agriculture (1967), and the Award for Outstanding Teaching Performance, Purdue University (1969).

Among Dr. Paarlberg's more than one hundred publications are three books: *Food, American Farm Policy,* and *Great Myths of Economics.* He has served as advisor to foundations, governments, community leaders, universities, and professional organizations. Since March 1969 he has been Director of Agricultural Economics, U.S. Department of Agriculture. In this capacity Don Paarlberg continues his dedicated service to American agriculture as advisor, administrator, and policy-maker.

Rainer Schickele

Former Director, Land and Water Division, Food and Agriculture Organization of the United Nations

Former Associate, Agricultural Development Council, Inc.

Author, Agricultural Policy, *1954;* Agrarian Revolution and Economic Progress, *1968*

Rainer Schickele has made extensive professional contributions, but beyond these is the nature of the man. He is always curious, always ready to question conventional wisdom, always friendly and courteous, and always concerned with the individual. He has a capacity to stimulate thinking, stir the imagination, and draw forth comments from others. Thus he has had a powerful impact as a teacher, colleague, and advisor that has gone well beyond his contributions as an economist.

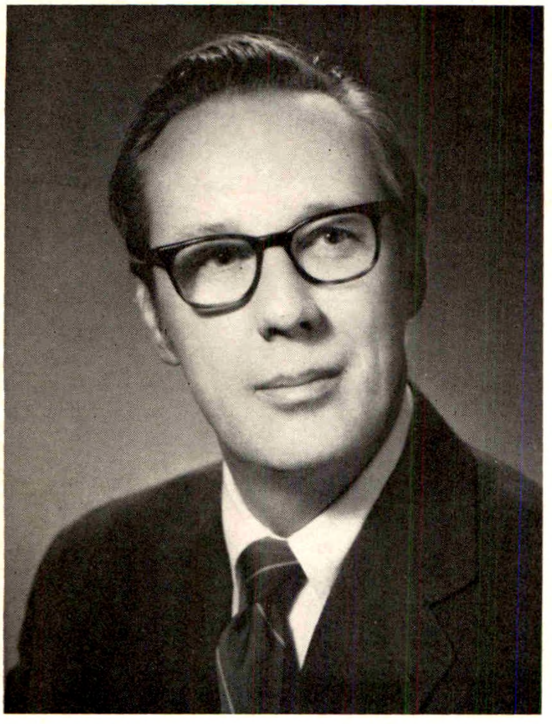
Dr. Schickele has made his contributions in a variety of organizations and roles. He has been a faculty member at Iowa State University, North Dakota State University, the University of Ceylon, and Michigan State University. He served in the U.S. Department of Agriculture, and for eleven years was director of the Land and Water Division of the Food and Agriculture Organization of the United Nations. In the latter role he was administratively responsible for a $10 million technical assistance program with a headquarters staff of 60 professionals and about 450 experts in approximately 60 countries. His most recent foreign assignment was for the Agricultural Development Council where, as an Associate, he was regional representative for the Council in Ceylon and South India and visiting professor at the University.

Rainer Schickele is widely recognized for his numerous writings in his area of agricultural policy, land tenure, and agricultural development. His two books, *Agricultural Policy* and *Agrarian Revolution and Economic Progress* are well known at home and abroad.

His focus on agricultural policy has carried him around the world. In the United States and abroad he has brought to agricultural policy a humanity and concern for the individual often lacking in other policy analyses.

Born in Germany in 1905, he spent the early years of his academic career in Europe. He received his Ph.D. from the University of Berlin in 1931 in the field of agricultural economics and policy.

Dr. Schickele's work in research and teaching has been recognized in the academic profession by various prizes and awards, including a research fellowship from the Brookings Institution, and a post-doctoral fellowship of the Social Science Research Council.



Vernon W. Ruttan is director of the University of Minnesota Economic Development Center as well as professor in the Department of Agricultural and Applied Economics and in the Department of Economics. From 1965 to 1970 he was head of the Department of Agricultural Economics.

A native of Michigan, Dr. Ruttan studied at Michigan State University, Yale University, and the University of Chicago. After serving for three years as economist with the Tennessee Valley Authority, he went to Purdue University as professor of agricultural economics and later served as a staff economist with the President's Council of Economic Advisers and as an economist for the International Rice Institute in the Philippines. He also has been a visiting agricultural economist with the Giannini Foundation of Agricultural Economics at the University of California, Berkeley.

Dr. Ruttan has conducted research and written extensively in the fields of technological change, resource utilization, location, and regional development. His book, *The Economic Demand for Irrigated Acreage,* received the American Farm Economic Association Publication Award for 1966; and in 1967 his article, "Agricultural Policy in an Affluent Society," won the Association's Best Article award. His most recent book, *Agricultural Development: An International Perspective,* has been published this year. He has been a member of the Economics Institute Policy and Advisory Board and of the Asia Society's Southeast Asia Development Advisory Group and is currently a member of the Board of Trustees of the Agricultural Development Council and of the Minnesota Governor's Council of Economic Advisors and a consultant to the Agency for International Development and the International Institute of Tropical Agriculture.

PRESIDENTIAL ADDRESS

Technology and the Environment*

VERNON W. RUTTAN

A BELIEF that the application of science to the solution of practical problems represented a sure foundation for human progress has been a persistent theme in American intellectual and economic history [26, 64]. During the two decades following World War II this belief was seemingly confirmed by the dramatic association between the progress of science and technology and rapid economic growth. The technological revolution in American agriculture, the growth of industrial productivity, the contributions of science to military and space technology, and the virtual elimination of the business cycle seemed to reinforce this perspective.

By the late 1960's, however, the formula that had permitted the United States to move into a position of scientific, economic, and political leadership in the world community was faced with both an intellectual and a "populist" challenge.[1] A view has emerged that the potential consequences of the power created by modern science and technology—reflected in the cataclysm of war, degradation of the environment, and psychological cost of rapid social change—are obviously dangerous to the modern world and to the future of man. The result has been to seriously question the significance for human welfare of scientific progress, technical change, and economic growth.

Three Generalizations

In my judgment the response by economists to the challenges posed by these concerns has been overly defensive. Nevertheless, it seems useful to reemphasize certain considerations that have frequently been ignored in the heat of the challenge to economic thought and economic policy. Let me summarize my own perspectives in the form of three generalizations.

First, man has throughout history been continuously challenged by the twin problems of (a) how to provide himself with adequate sustenance and (b) how to manage the production and disposal of what in recent literature has been referred to as "residuals," in less elegant language as garbage [43]. Failure to make balanced progress along both fronts has at times imposed serious constraints on society's growth and development.[2] The current environmental crisis represents, in my view, one of those reoccurring times in history when technical and institutional change in the treatment of residuals has lagged relative to progress in the provision of sustenance, conceived in the broad sense of the material components of consumption.

Second, in relatively high-income economies the income elasticity of demand for commodities and services related to sustenance is low and declines as income continues to rise, while the income elasticity of demand for more effective disposal of residuals and for environmental amenities is high and continues to rise.[3] This is in sharp contrast to the situation in poor countries where the income elasticity of demand is high for

* University of Minnesota Agricultural Experiment Station Scientific Journal Series Paper 7732. The author is indebted to Victor Arnold, Blair Bower, Willard Cochrane, Ralph Comstock, Yujiro Hayami, Ralph Hofmeister, John Krutilla, Wilbur Maki, Philip Raup, John Richardson, T. W. Schultz, Kerry Smith, Jerome Stam, and John Waelti for critical review of an earlier draft of this paper. The research on which this paper is based was supported in part by a grant from The Rockefeller Foundation.

[1] The populist literature is typified by Reich [66] and Ehrlich [28]. For a more serious treatment of the same issues see Commoner [23], Ehrlich [29], Mumford [56], and Caldwell [17]. Among economists Boulding [10, 11] and Mishan [51, 52, 53] have been particularly outspoken.

[2] "The ancient urban centers also confronted a problem that continues today: the disposal of garbage and rubbish . . . life must have been unsanitary, unsightly and odoriferous, at least to the great masses of the poor. The evidence suggests the prevalence of high mortality rates. Many ancient cities appear to have been literally buried in their own rubbish" [16, p. 117]. See also Rosen [68] and Caldwell [17]. Anyone who has traveled extensively in poor countries will recognize that Brown's description remains valid for even small communities living near the subsistence level. In poor communities use of energy to dispose of residuals is directly competitive with use of energy to provide for sustenance.

[3] Quantitative evidence with respect to the demand for environmental services is inadequate at this time.

VERNON W. RUTTAN *is professor in the Department of Agricultural Economics and the Department of Economics and director of the Economic Development Center at the University of Minnesota.*

sustenance and low for environmental amenities. The sense of environmental crisis in the relatively affluent countries at this time stems primarily from the dramatic growth in demand for environmental amenities.

Third, the capacity of a society to solve either the problem of sustenance or the problems posed by the production of residuals is inversely related to population density and the rate of population growth and is positively related to its capacity for innovation in science and technology and in social institutions. I take it as axiomatic that population growth is competitive with improvements in the quality of life in poor countries and that achievement of a population growth rate well below 1.0 percent per year within the next generation would represent a highly desirable policy objective for all nations. At the same time it is clear that in the high-income countries of the West and in Japan neither current nor projected population growth represents, in the foreseeable future, a serious constraint on the capacity to provide desirable increments in both sustenance and environmental amenities [48]. *The advance of science and technology has enabled modern society to achieve a more productive and better balanced relationship to the natural world than in the ancient civilizations or in the earlier stages of Western industrial civilization.* And continued technical advance is essential for further advances in both the material and aesthetic dimensions of culture. The fundamental significance of technical change is that it permits the substitution of knowledge for resources or of less expensive and more abundant resources for more expensive resources, or it releases the constraints on growth imposed by inelastic resource supplies. In this perspective the rhetoric about "finite earth" is clearly misleading. The impact of science and technology has been to expand the size of "spaceship earth" along those dimensions that are most significant for human existence.

Resource Requirements for Growth

Let me now return to the resource requirements for growth. We are now in the second major wave of concern with natural resource policy since World War II, the fourth since Malthus [8]. The first postwar wave of concern, in the late 1940's and early 1950's, focused primarily on the quantitative relations between resource availability and growth—the adequacy of land, water, energy, minerals, and other natural resources to sustain growth. The reports of the President's Materials Policy Commission [62] and the President's Water Resources Policy Commission [63] were the landmarks among the postwar resource assessment studies generated by this wave of concern.

A basic issue in these studies was an operational definition of scarcity. Physical indicators were clearly inadequate and misleading. The scarcity implications of indicators such as estimated reserves of energy and mineral resources and the productive potential of agricultural land failed to materialize. Indeed, surpluses of resource products have frequently been apparent even as scarcity predictions were announced.

In 1952 the President's Materials Policy Commission concluded that "in the U.S. the supplies of the evident, the cheap, the accessible are running out" [62]. However, during the last decades we have enhanced our ability to upgrade old resources, to discover new ones, to utilize them more efficiently, and to adjust to changes in relative resource availabilities. There has been a decline in the resource component of national output and both an absolute and relative decline in employment in the resource sectors [4]. If the Materials Policy Commission were writing today it would have to conclude that there have been abundant examples "of the nonevident becoming evident; the expensive, cheap; and the inaccessible, accessible."

Clearly an operational definition of resource scarcity requires an indicator that reflects economic as well as technical considerations. After a decade of methodological discussion and technical debate it has generally been accepted by economists and by knowledgeable scientists and resource program administrators that our price system provides the most effective indicator available of both absolute and relative resource scarcity [4]. A secular increase in the price of the product of a resource industry (crude oil or wheat, for example) relative to the general price level can be regarded as a reasonably accurate indicator of resource scarcity. Similarly, a secular decline in the real price of the products of a resource sector can be regarded as an indicator of a reduction in scarcity. In fact, the relative prices of most broad classes of resource products (forestry, minerals, agriculture) have been declining. Some resource products, the nonfuel minerals for example, are intermittently plagued with specific shortages (copper, sulfur, tin, etc.); but a stretch of high prices has not yet failed to induce successful efforts to locate new deposits, exploit old ones, and promote substitution of more abundant for relatively scarce resources [47, 61].

There has been some questioning during the last several years of whether these propositions remain as firmly grounded in empirical fact as they appeared to be in the early 1960's [57].[4] For example, there has been rising concern about energy shortages and the drain that economic growth in developed countries places on world resources [83]. The current energy "crisis" appears to reflect institutional contraints on allocative mechanisms and the increasingly effective efforts of raw material producing countries to broaden their shares of the economic rent from exploitation, rather than technological or resource contraints [76, 84]. And the stress that economic growth in the United States and other rich countries is placing on world resources appears to reflect excessive investment in military and space technology and effort, which is not only excessive when evaluated in terms of net social return on a global basis but is relatively intensive in its demands on energy and materials resources.[5]

Demand for Environmental Services

In this second postwar wave of concern with natural resource policy our traditional concern with the adequacy of the natural resource base to sustain growth has been supplemented by intense concern with the stress on environment associated with economic growth. We are now experiencing the effects of a rapidly rising demand for environmental services pressing against a relatively inelastic supply. The rising demand is derived from two sources: (1) a rising demand for the environmental assimilation of residuals, derived from growth in commodity production and consumption plus the energy production and transportation services associated with commodity production and consumption [43, 71]; and (2) a rapid growth in consumer demand for environmental amenities—for direct consumption of environmental services—arising out of rapid growth in per capita income and a high income elasticity of demand for such environmental services as freedom from pollution and congestion.[6] Rising competition between the demand for environmental services for disposal of residuals and the demand for resource amenities is producing a dramatic rise in the economic value of common property resources formerly regarded as free goods [31, 43].

As economists have worked with other environmental scientists on issues related to demand and supply of environmental services, the problem of operational definitions of demand, supply, and scarcity has again risen as a central concern in resource economics. It is again apparent, as when the concern was primarily with the quantitative or materials (or resource input) dimensions of resource policy, that physical criteria (algae bloom, sulphur dioxide and carbon dioxide concentration in the air, biochemical oxygen demand (BOD) levels and concentrations of nondegradable pollutants in streams or lakes, destruction of rare natural environments) are by themselves no better guides to the solution of resource and environmental policy issues than in the past. It is clear that any analytical system that will improve our capacity to arrive at an operational definition of scarcity must be capable of integrating physical and biological information with economic, social, and behavioral knowledge on both the demand and the supply side.[7] This is an essential step in the establishment of priorities for investment and management.

In addition to conceptual difficulties there is a basic lack of data about the ecosystem. My own reading of the literature leads me to the conclusion that no one knows with any useful degree of precision the extent to which the basic metabolic processes of the biosphere are being disturbed by activities leading to environmental modification. And there is even less information as to whether

[4] Robert Manthy of the Department of Forestry of Michigan State University is engaged in a major study designed to update the Potter-Christy and Barnett-Morse time series data on resource consumption and prices.

[5] The assertion rests on inadequate documentation.

[6] I find Rothenberg's classification very helpful: "(1) Pure congestion is the case where all users generate identical rates of quality interference per unit of activity and share equally in the resulting quality impairment; (2) pure pollution is the case where some users generate very high rates of unit interference while others generate zero rates and only the latter experience quality impairment; (3) the general case is where all users both generate impairment and share it. . . . The variety of both abuse and victimization prevents an easy or complete categorization of users into guilty and innocent" [71, p. 115].

[7] "There has developed in the contemporary natural sciences a recognition that there is a subset of problems, such as population, atomic war, and environmental corruption, for which there are no technical solutions. There is also an increasing recognition among contemporary social scientists that there is a subset of problems, such as population, atomic war, environmental corruption and the recovery of a livable urban environment, for which there are no current political solutions. . . . The common area shared by these two subsets contains most of the critical problems that threaten the very existence of contemporary man" [23]. The article by Crowe was written in response to an earlier article by Hardin [31].

the effects of the occurring environmental modifications are, on balance, favorable or unfavorable to the future of the human environment—to the future of man.[8] There can be no question, however, that the problems of environmental congestion and pollution have achieved serious dimensions in specific localities and regions and that the casual use and diffusion of certain materials, such as chlorinated hydrocarbons, represents a serious threat to environmental stability, public health, and economic activity.

With the exception of work on the economics of recreation services and cultural amenities, economists have not seriously tackled the problem of providing quantitative measures of the demand for resource amenities.[9] Nor do we have a generally accepted theory of aesthetics that can serve as an effective guide to nonmarket choices in the ordering of priorities for investments designed to provide the resource amenities for which the market fails to make adequate provision [46]. We have as yet no clearly acceptable guides to priorities in public policy with respect to environmental quality.

Induced Technical Change

Recent debate with respect to environmental policy has tended to polarize around two alternatives. One is the anti-growth movement. Boulding [10, 11] and others have suggested a model, based on analogy with the bioecological model of a stable equilibrating system, which suggests the necessity of redirecting economic activity to limit the environmental stress resulting from human intrusions on the natural environment. My own inclination is to emphasize a second alternative, the redirection of technical effort to permit continued acceleration of the performance of the ecosystem.

Technical effort can be redirected toward reducing environmental stress. This alternative has been disregarded in much of the literature of the "environmental crisis." In past this stems from the positive, almost metaphysical, value placed on "equilibrium" in the bioecological model. In my judgment it stems to an even greater degree from a view that progress in science and technology is essentially autonomous-unresponsive to social and economic forces.[10] By and large, this view has remained unchallenged by the historians and philosophers of science and by most social scientists. In economics, for example, technological change has typically been treated as exogenous to the development process.[11]

Recent theoretical and empirical investigations, however, are resulting in a new perspective which views technical change as a dynamic response to resource endowments and to the social and economic environment. Hicks suggested, as early as 1932, that the direction of technical change could be influenced by changes or differences in the relative prices of factors of production [40]. This view was challenged by Salter [73, pp. 43–44]. The dominant view in economics has been that firms are motivated to save total cost for a given output; at competitive equilibrium each factor is being paid its marginal value product; therefore all factors are equally expensive to firms; hence there is no incentive for competitive firms to search for techniques to save a particular factor.[12] The major weakness of this argument was the failure to recognize that the process of technical change is itself a resource-using activity. It is now clear that much of scientific research, and a large part of education and training, can for purposes of economic analysis be regarded as resource-using activities producing new forms of physical and human capital that are more efficient than older forms [75, p. 20].

As prices change, firms are not limited to simply reallocating resources among known technical alternatives—along the neoclassical production function. They can instead allocate resources to

[8] For a definitive statement of the current state of knowledge with respect to environmental problems of worldwide significance see SCEP [80, 81]. For a useful review of the current state of knowledge with respect to agricultural and agriculturally related sources of pollution see the papers presented at the symposium on *Agriculture and the Quality of Our Environment* [13], the symposium on *Pollutant Impact on Horticulture and Man* [2], and the symposium on *Economic Research on Pesticides for Policy Decisionmaking* [82]. For a more popular, and sometimes populist treatment see Harte and Socolow [32].

[9] The burgeoning literature in the field of recreation economics derives largely from Clawson's formulation [18, 19]. The work of Baumol [6, 7] has occupied a similar role in the economics of cultural amenities.

[10] "Notwithstanding occasional declarations about its unlimited potentialities for social betterment, since is not guided by any social purpose. As with technology, the effects on humanity are simply the by-products of its own self-seeking. As a collective enterprise science has no more social conscience than the problem-solving computers it employs. Indeed, like some ponderous multipurpose robot that is powered by its own insatiable curiousity, science lurches onward. . . ." [52, p. 129].

[11] See, for example, the literature assembled by Rosenberg [70].

[12] For a review of the literature on induced innovation see Ahmad [1]; Hayami and Ruttan [34]; Smith [77].

open up new technical opportunities, which expand the scope for factor substitution, along a perceived innovation possibility frontier or metaproduction function. Introduction of this perspective has led to an extension of the neoclassical theory of the firm to demonstrate that it is rational for firms to allocate research and development resources to facilitate the substitution of increasingly less expensive factors for more expensive factors.[13]

The basic limitation of the theory of induced innovation as it now stands is that the discussion has been conducted entirely within the framework of the theory of the firm. *There is no theory of induced innovation in the public sector.* But development processes are not limited to those that are well understood or have been adequately modeled. The specific mechanisms that act to induce technical change in the private sector are a subset of the more complete set of processes that induce learning behavior in the direction established by social priorities within a wide variety of institutional settings.

Empirical investigation of the induced innovation process has not been constrained by the lack of a fully articulated theory of induced innovation. Schmookler's definitive studies suggest that while autonomous discoveries in pure science (those unmotivated by technical or economic objectives) sometimes provide the stimulus for technical change in the science-based industries, most technical change derives from the recognition of a technical problem or opportunity evaluated in economic terms [41, 69, 74].[14]

The work that Yujiro Hayami and I have recently completed goes beyond the earlier literature to demonstrate historically the effective operation of an induced innovation mechanism in public sector research and development similar to the Hicksian theory of induced innovation in the private sector [33, 34]. In both Japan and the United States a common basis for rapid growth in agricultural output and productivity was the adaptation of agricultural technology to the sharply contrasting factor endowments in the two countries. In both countries public and private sector agricultural research developed a remarkable capacity to generate a continuous sequence of innovations in agricultural technology biased toward removing the most serious constraints on growth of agricultural output. In Japan these innovations were primarily biological and chemical. In the United States they were primarily mechanical and engineering. Only in the last several decades has there been what appears to be a movement toward convergence in patterns of technical change in the two countries.

Our empirical tests of the induced innovation hypothesis clearly support the conclusion that the enormous changes in factor proportions and in factor productivity represented a process of dynamic factor substitution associated with nonneutral changes in the production surface induced by secular shifts in relative factor prices. In both the United States and Japan the progress of public sector agricultural research has been powerfully directed by the conditions of resource supply and product demand to the extent that these forces were reflected through factor and product markets. There is also evidence to suggest that in recent years, when the implications of market forces in both factor and product markets have been partially obscured by nonmarket constraints on resource use, there has been substantial misallocation of public sector agricultural research resources.

Let me emphasize that the model of induced innovation that we have developed remains incomplete. It does not possess formal elegance. It does not adequately explain the feedback process by which public sector resource allocation responds to relative factor endowment and factor accumulation or to environmental stress. It has been argued that the failure of public sector allocative processes stems from the absence of an adequate feedback mechanism linking the "political objective function" to performance [14, 60]. For the United States, however, there is a clear presumption that the existence of a decentralized agricultural research system, the state agricultural experiment station, effectively simulated the innovative behavior postulated by the theory of induced innovation.

Induced Institutional Innovation

The rapid rise in the economic value of environmental services is placing increasing stress on traditional social institutions developed in an environment in which access to "common property" environmental services was regarded as a free good. Under present institutional arrangements certain elements of the physical and social environment continue to be undervalued for purposes of market transactions, even though they have become common property resources of great and

[13] Ibid.

[14] Easterlin [27] has utilized an inducement perspective in his analysis of the long-term decline in human fertility in the United States.

increasing value.[15] The effect has been to bias the direction of technical effort toward excessive production of a wide range of residuals and spillover effects.

In this view the environmental stress resulting from pollution and congestion is not simply a by-product of the autonomous forces of technical change. The system of legal and economic institutions that govern the use of common property resources has failed to evolve in a manner consistent with (a) the rising demand for capacity to receive and assimilate the residuals resulting from commodity production and consumption and (b) the shift to the right in the demand for resource amenities associated with high and rising per capita incomes. The effect of continued undervaluation of environmental services has been to induce a pattern of technical change biased in the direction of excess residual production and away from increased efficiency in the supply of resource amenities [43, 77].

Let me emphasize this point. Traditional production theory implies that if the price of a factor input is zero (or close to zero) that factor input will be used until the value of its marginal product approaches zero. This will occur even though the marginal social product may be negative. In an environment characterized by rapid economic growth, technical change induced by relative factor prices will result in a bias in the direction of technical change, and the demand for a resource that is priced below its social cost will grow more rapidly than in a situation where substitution possibilities can occur only along a "given" production surface. As a result, the "common" resource (the capacity of the environment to absorb residuals, for example) will undergo stress more rapidly than in a world characterized by a constant level of technology, or even by "neutral" technical change. The effect is to accelerate the widening of the gap between the private and social costs of environmental services.

This process has been clearly apparent in agriculture. One effect of the agricultural commodity programs has been to make land more expensive [38]. At the same time, the capacity of the environment to absorb the residuals from crop and livestock production has been treated as a free good. As a result, scientific and technical innovation in both the public and private sectors has been overly biased toward the development of land substitutes—plant nutrients and plant protection chemicals and crop varieties and management systems that reflected the overvaluation of land and undervaluation of the social costs of the disposal of residuals from agricultural production processes.[16] In retrospect it seems apparent that the same biases in factor prices have led to underinvestment in technological effort directed toward pest and soil management systems consistent with the social value of environmental services.

Such examples are not of course restricted to agriculture. Nor do I want to underestimate the positive contribution of the programs initiated in the 1930's and 1940's to stabilize an inherently unstable sector of the economy and to reduce soil erosion, a dominant environmental issue a generation ago. The significance of the example is simply that the environmental stress now being experienced would have occurred more slowly in an environment in which the direction of technological effort was not itself responsive to distortions in the pricing of both conventional factor inputs and environmental services.

Redirection of technical effort in response to the rising economic value of environmental services will involve complex interaction between technical and institutional change. Extension of the theory of induced innovation to include the process of institutional innovation adds significantly to our understanding of this process. *It seems consistent with historical experience to view institutional change as resulting from efforts of economic units (households, firms, bureaus) to internalize the gains and externalize the costs of economic activity and efforts by society to force economic units to internalize the costs and externalize the gains.* Where internalization of the gains of innovative activity are difficult to achieve, institutional innovations involving public sector activity become essential. The socialization of much of agricultural research, particularly the research leading to advances in biological technology, represents an example of public sector institutional innovation designed to realize for society the potential gains from advances in agricultural technology. The political and legislative history of farm price programs, from the mid-1920's to the present, can be viewed as a

[15] The reader is referred to Bator [5] for a review of economic thought with respect to the sources of market failure. See also Kneese [44].

[16] Headley [36] estimates that if the present land held out of production by government programs were returned to production, present levels of output could be maintained with pesticide use at about 20 percent of present levels. See also Headley [35, 37], Brewer [15], and Heady [38].

struggle between agricultural producers and society generally regarding the partitioning of the new income streams resulting from technical progress between agricultural producers and consumers.

The environmental movement, in spite of its extra baggage (including its extensive "demonology" and its resurrection of discarded concepts from the underworld of science) is contributing to the creation of a social and political environment in which it may become feasible to more adequately institutionalize the redirection of technological effort and carry through the reforms necessary to redefine the ownership rights in an increasingly valuable set of common property resources.

Guidelines for Environmental Policy

It seems clear at this time that any significant progress in resolving the conflict arising out of growing demands for environmental services must involve a redefinition of property rights in such a way that innovative activity in both the private and the public sector can be appropriately guided by explicit and pervasive economic and social incentives. This is of course not a new process in western economic development; the modernization of land tenure relationships, including the elimination of the commons and the shift from share tenure to lease tenure and owner-operator cultivation in much of western agriculture, was in large part the result of an effort to achieve a system of property rights that would permit individual farmers to internalize part of the gains from innovative activity.

I would like to suggest several guidelines for the institutional reforms that are now needed if we are to achieve effective development and management of our environmental resources.

First, the principal limitation of the ecological perspective stems from its preoccupation with the adaptive behavior of an interdependent biological community under a stable set of ecological interrelationships [25]. But the concept of equilibrium, however valid it may be as an analytical tool, is clearly misleading as a guide to environmental policy and planning. Robbins [67, p. 143] taught us years ago that in economics "equilibrium is just equilibrium." There have been similar challenges in ecology to the "climax" theories of ecological succession [65].

Much of recent discussion of resource and environmental policy has in my view been too narrowly based (a) on analogies with stable, or even "dynamically" stable, microsystems borrowed from bioecology and (b) on the ultimate global implications of basic geophysical principles [30]. These models provide too little scope for learning behavior leading to the higher levels of system performance that are characteristic of viable social systems. The discount rate that I apply to my own activity forces me into a somewhat shorter time perspective than the eventual "running down" of the universe implied by the second law of thermodynamics. Comments that the levels of production and consumption, rather than the form of production and consumption technology, determine the environmental impact because they do not "reduce the mass of residuals but only change their form" are not particularly enlightening. The form, location, and durability of residuals is a central issue! The implications for quality of life of the discharge of raw sewage in the Potomac River and of organic wastes from sugar beet processing in the Red River Valley is not a simple function of the size of the biochemical oxygen demand (BOD) imposed on regional watercourses.[17]

Second, the historical decline in relative importance of the natural resource component in economic activity, resulting from technical change and changes in consumer behavior, means that we have already sharply reduced the cost of preservation of a broad class of resource amenities. In a relatively affluent society we give up very little real economic growth by the preservation of rare natural amenities [46]. Failure to harvest the timber or mineral resources of the Boundary Waters Canoe Area or the High Sierras or to develop the potential power resources of unique natural features such as the Grand Canyon or Hell's Canyon will have no measurable impact on national economic growth.

Third, redirection of scientific and technological effort along a path induced by environmental stress is an essential component of any effort to achieve consistency between viable development of the social environment and the natural environment. The capacity of the social system to achieve substantial increases in performance will depend on its ability to achieve productivity growth—to identify new and more efficient sources of growth in the supply of social and environmental amenities [6]. Agriculture, for ex-

[17] Lŏf and Kneese [49] estimated that in 1950 the sugar beet industry alone accounted for 15 percent of organic wastes coming from all industries. The water residuals load generated by sugar beets has been substantially reduced since that time by process alterations.

ample, can never again release as many workers to other sectors of the U.S. economy as it released during the last four decades. It can never again serve as a "leading" growth sector [72]. I see little likelihood, for example, that alternative transportation systems will replace automobile transportation in the near future unless such systems can yield growth dividends in the form of real cost reductions, including user inputs of time [55].

The redirections of effort, in both the natural and social sciences, toward those areas of social conflict arising out of environmental stress represents an exceedingly difficult challenge to institutional innovation. Much of the investment to support this effort, particularly in the areas of biological technology and the social sciences, must come from the public sector. The spillover effects are so great that there is little inducement for private sector investment to produce the knowledge about the basic physical, biological, and social relationships necessary to resolve the conflicts associated with environmental stress and institutional change.

The public sector has traditionally experienced great difficulty in generating support for research designed to produce social change. There has been an implicit acceptance of the Marxian view that the "mode" or the technology of production should dominate social organization [9, 50]. Let me attempt to clarify. When society invests in plant or in medical science research it anticipates a payoff in terms of technical change—higher national average crop yields and lower mortality rates. When society invests in social science research it anticipates that the results will contribute to the "conservation" of existing social institutions. Yet radical changes in family life, religion, and social and economic organizations have clearly been induced by the sharp decline in the cost of population growth resulting from advances in agricultural and health technology. These changes serve to identify the public health and agricultural scientist, not the economist, the psychologist, the sociologist, or the political scientist, as the major source of radical social change in our time. Yet the easiest way for a social science research project to get its budget cut off is to consciously design a research program to produce social change. This "head-in-the-sand" approach to institutional innovation, with its pretense of ethical neutrality, is exceedingly costly to society and may be dangerous to the future of man [25, p. 217].

Fourth, as a general system of environmental management the regulatory approach is a dead end. The history of direct federal or state regulation of large industries is characterized by consistent failure when evaluated either in terms of equity or efficiency. Under the best of circumstances the decision process of the regulatory agencies have become hopelessly mired in technical, legal, and administrative overburden. And over the longer run the regulators have tended to become instruments of the regulated.[18]

This is not to argue that the regulatory approach is not of value in specific instances. A major source of current concern with the impact of technology on the environment is the accelerated rate of advance in science and technology relative to the rate of institutional change. It has also been argued that biological and social systems are characterized by threshold or overload phenomena: "The road that suddenly jams up when one more car appears on it, the river that refuses to clean itself up under a single addition of sewage . . ." [12]. These characteristics clearly call for investment in a much more extensive system of monitoring and assessment of environmental, technological, and social change [58, 80, 81]. The potential payoff to more sensitive monitoring of these systems is extremely high. Direct regulation and prohibition is clearly called for to prohibit those types of environmental pollution from which health hazards and aesthetic offense is obvious, dangerous, and immediate. I also agree with Mishan [52, 53] that direct legal prohibition should be reexamined in terms of its effectiveness in redirecting technical effort.

For the present, however, I would confine subsidization, direct prohibition, and regulation to a much smaller role than in current environmental policy. The decision-making and allocative capacities of both the legislative and judicial systems are clearly overloaded [22]. Institutional systems must be sought that are capable of internalizing incentives for environmental management. Let us hope it will be possible to avoid some of the mistakes which have resulted in the confusion of public and private property rights in water and have contributed to our failure to take fuller advantage of market mechanisms in the allocation of water resources. Clearly the implications—technical, legal, economic, social—of al-

[18] Regulatory agencies seem to have a common life cycle in which the last stage involves staffing of the agency administration from the ranks of the regulated. See Kohlmeier [45], Stigler [79], and the literature cited by Crowe [23].

ternative forms of pollution rights and the organization of "markets" in pollution rights should be well up on the research agenda. There is some indication that this perspective is now receiving more serious consideration in environmental legislation [59].

Fifth, the system of information linkages and incentives designed to guide consumption and production activities and technological effort must be pervasive. The necessary behavior modifications are not confined to the decisions of a few corporate executives or national level decision-makers. Nor can they be achieved through a public relations effort to inspire a new "ethics of conservation."[19] The spatial characteristics of supply and utilization of environmental services represents a serious constraint on the centralization of environmental decision processes. By and large, situations characterized by serious environmental stress are relatively location specific. It is primarily at the level of the region or locality that serious environmental stress occurs and that intensive monitoring and management efforts must be undertaken [43, 44].

The formal analysis on which we can draw for environmental and resource planning and policy is seriously deficient. Analytical capacity seems limited to models which employ, either implicitly or explicitly, inelastic supplies of commodity inputs and environmental services, fixed technical coefficients, highly aggregated production and consumption activities, and "given" consumer tastes [3, 21, 43, 44, 54, 78]. The information requirements of the more sophisticated models that are available seem to preclude their implementation. And even the most advanced models seem unable to incorporate the dynamic properties of the world with which most of us are familiar, including induced changes in technology and the response of consumer tastes and behavior to new opportunities.

This leads me to search for an alternative to "environmental management," in the narrow sense of the term, and to concentrate on the institutional modifications consistent with decentralized decision processes. I see no feasible alternative but to search for institutional innovations capable of establishing property rights with respect to environmental subsystems; the establishment of firms or authorities with appropriate incentives to manage such subsystems; and the use of market or market-like mechanisms to direct the use and production of commodity and service inputs and outputs of such systems [24].

The available analytical models provide weak guides to managerial decision processes by a hypothetical world or national environmental control authority. Yet they do provide some insights into the behavior of households, firms, and bureaucracies—information that is essential in the design of environmental policies to guide the behavior of the firms or authorities established to manage specific environmental subsystems. It seems likely, for example, that the extent to which relative factor and product prices for resource commodities and services reflect relative resource endowments and consumer preferences they will also serve to induce an "efficient" path of technological effort by private and public sector firms, bureaus, and authorities.

Finally, I would like to emphasize that the environmental crisis is not primarily a problem of crisis in man's relationship to nature. Rather it is only one element of a more pervasive crisis in the sociopolitical environment. In most respects, however, the technical difficulties associated with reversing environmental deterioration may be relatively easy. In the case of sociopolitical deterioration the process may be cumulative [42]. In my judgment it is much more important to concern ourselves with deterioration in the sociopolitical environment than of the physical environment.

[19] "The internalizing of new roles of conduct is essential to the effectiveness of ethics in society, but it cannot be obtained solely through efforts focused upon the values and behavior of individuals. . . . Ecologically valid ethics can not be effective until they are internalized in individuals and externalized in social institutions" [7, p. 298].

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The Changing Political Economy of Higher Education and Its Significance for United States Agriculture*

C. O. McCorkle, Jr.

Francis Bacon observed that "adversity is not without comforts and hopes." Higher education in the United States today, whether viewed from a financial, social, political, or to some extent even from an academic perspective, is certainly showing the marks of adversity. If Bacon implied any inverse proportionality it is difficult to detect, for comforts are few and hopes, while numerous, are far from being fulfilled.

In dealing with this extremely broad assignment I have attempted to abide by the request of President Hillman that I comment from the vantage point of "one who is struggling with the fundamental issues in turning the educational octopus around and in making hard decisions after a tremendous growth period in United States education." His use of the term "struggling" is accurate. His reference to hard decisions would have been more accurate had he also included the term "unpopular." As to whether the issues being faced are the fundamental issues time will judge. "Turning the educational octopus around" is an inaccurate description of what is happening. I hope this becomes clear as we proceed.

I shall begin by sketching briefly some major trends in American society that are shaping attitudes toward all of our institutions, including our colleges and universities. Within this framework the present financial plight of higher education can be more meaningfully discussed. A review of how institutions are responding and should respond to the more fundamental forces that appear to be shaping the future of higher education, as well as to the more immediate financial pressures, leads into a discussion of the impact some of these adjustments in higher education are having specifically on agriculture, although my emphasis on agriculture per se may appear too limited. I conclude with some observations on strategies that may assist in strengthening appropriately higher education's position in our society.

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Growth, Change, and Crisis: The University Today

Our time is characterized by organizations, often huge organizations, and our society is in large measure an organizational society. They constitute society's principal mechanism to provide for common needs and for protection of persons and resources. Our assent to the system is understood to be exchanged for the benefits that only these social instruments can bestow.

Our society has become heavily dependent on organizations and, their ineptitude or failure can have shattering consequences for individuals, communities, and nations. Organizations of course are not uniquely modern. What distinguishes the modern organization from its antecedents is not so much its bewildering complexity as its rationality and efficiency. The crisis in confidence in public education, however, cannot be blamed totally on rationality and efficiency. It is rather to change and to the pace of change (the society in flux) that we must turn for an understanding of the forces that shape our institutions and their present troubles.

We have been bombarded within the span of a single lifetime by changes that have affected in a radical way how we view ourselves, our institutions, and our society. Life styles, attitudes, interests, expectations, needs, and values of our people have been significantly altered. The American university has been centrally involved in giving rise to change and is a pivotal institution in contemporary society. It is the chief institution for discovering, organizing, evaluating, and transmitting knowledge. In a very real sense "knowledge itself is power." Thus, the university is a prize to be sought and secured by those who would sustain the established order as much as by those who would dismantle it. The turmoil on our campuses results not only from efforts to destroy the university, but also, and perhaps to a greater extent, from the competition of its suitors —competitors whose dissimilar social, political, and economic goals affect directly the vitality of the essential linkages between the university and the larger community.

For the university the problem is especially

complicated by the pronounced difference in values between those it is responsible for educating and those who provide resources to the university for carrying out this task. While many of the differences are trivial, many others are substantive and have profound implications. There are, for example, basic differences about the value, worth, importance, and relevance of private property. And student concepts of personal responsibility, self-discipline, and societal responsibility are equally at variance with the majority view.

Organized education, of course, is dominated not by students but by the priorities, aspirations, and behavioral preferences of the earlier generation whose own sense of identity, individual worth, and security have been formed by older and different values. Thus for the student to reject older values and the society they produced is to threaten not only the established order but also the educational requirements seen by him as designed to nurture and sustain it rather than change it. For the student to accept those values and institutions that currently prevail is to compromise his perception of the world in which he will live. Students are impatient with a system of education seemingly more committed to serving the established order than to preparing them for the social, cultural, political, and environmental dislocations with which their generation will be expected to cope. Their impatience, however, is rivalled by the sense of outrage in those who are offended and threatened by the students' ingratitude and by their demonstrations of discontent.

But the problems of the university do not end here, for along with most of the nation's other major institutions it also suffers from a very real and growing lack of credibility for reasons that may be only partially inferred from the preceding. The country as a whole is undergoing fundamental political change, a crisis of legitimacy. Confidence in formal authority and acknowledgement of it are waning for a variety of philosophical, social, and political reasons, and the legitimacy of the structure itself and the aims of its institutions are sharply questioned by significant numbers in our society. This erosion of confidence and trust has given voice to the demand that there be more consent of the governed, not less; more participation, more involvement, more influence, and more power in the formulation of decisions affecting the vital areas of one's life and work.

The impact of these forces on American higher education in recent years has been evident even to the most casual observer. In the universities the demand for a greater measure of involvement, despite all the publicity, is not confined to alienated students. On the contrary, we have found nearly everybody associated with higher education to be restless and unsatisfied. In varying degrees serious questioning bordering on alienation affects our legislative appropriations, gubernatorial policies on higher education, congressional legislation and federal contracts involving universities and colleges, and the activities and interests of some alumni, parents, and taxpayers. Disquiet seems to be a common thread running through otherwise diverse groups.

Reinforced by fiscal stringencies, legislatures and governors have hired analysts and management auditors to review budgets and operations much more closely than ever before. At the extreme, some in public office have attacked higher education as "unnecessarily expensive, as arrogant and unresponsive to public opinion, even as immoral and disloyal" [7, p. 81]. Fortunately, the harsher of these views are held by a small minority, but their frequent exposition has raised widespread suspicion with respect to higher education or at least some of its segments and activities. In any organization that has grown rapidly, diversified its activities, and attempted to reach new markets, all in a relatively short space of time as most colleges and universities have done, there are mistakes made and actions taken that can be legitimately criticized. In private organizations there are self-correcting mechanisms which act with reasonable dispatch. In public higher education, as with government, these mechanisms are largely nonexistent and should not exist. This has important ramifications for the adjustment process in higher education to be discussed subsequently.

While higher education is under criticism and fiscal pressures from public funding sources, it is ironic that these same sources are looking increasingly to colleges and universities as instruments of national power, as prime contributors to economic growth, and as suppliers of highly trained manpower. The inevitable rise in interdependence between government and higher education, while possibly increasing the effectiveness of service to the broader public interest has led to the rise in demand for public accountability and a concurrent erosion in institutional independence [10], a point to which I shall return.

Interwoven with these sources of question and pressures are the forces for academic reform which have been building up for a decade and which have emerged in the past eight years in the

midst of most unfortunate surroundings. These forces have focused on improved learning and learning environments with strong implications for traditional four-year on-campus lecture-oriented programs [16; 2]. By inference, the tight control exerted by faculty over academic programs has been attacked as being partially self-serving. And academic administrators are inferentially held responsible for lack of imagination and leadership in bringing the activities and structure of higher education into keeping with present-day needs of students and society. Much has been accomplished in this critical area, but the task ahead dwarfs accomplishments to date and interinstitutional and public communication of accomplishments must be improved.

Additional issues are exerting substantial influence in the shaping of public policy for higher education today. First is the question of future growth and enrollment patterns. Recent population statistics strongly suggest that in the absence of a marked increase in participation rate undergraduate enrollments could stabilize or actually decline after 1980. At the graduate level recent studies forecast a sharp drop in number of Ph.D. degree holders required to meet needs [3]. Graduate forecasts are based largely on academic market criteria. They do not differentiate clearly between fields of study, supplying institutions, or types of postgraduate education. In any case graduate growth may shift markedly toward the professional schools and away from the traditional Ph.D. programs. Such projections, while additional data for the decision-maker, must be recognized as highly uncertain, particularly as the planning period lengthens into the future. Those who take the position that the productivity of graduate programs is too low and those who say the monetary and net social costs associated with some of the more traditional programs are too high find comfort in these findings. The trends are widely known and are having an impact on both internal and external planning for higher education.

A second issue relates to the comparative roles of public and private universities. Mass public education of the highest quality as developed in the United States represents a large social investment, particularly for the individual states. Politically it is too often being looked on strictly as a cost, rather than an investment, difficult to meet currently and likely to demand additional resources in the future. In the absence of appreciation for the magnitude of the educational commitment in a relatively free and affluent society, the position is increasingly being taken that the private sector can and should carry a larger load, particularly in the more expensive fields of education such as medicine. There are also those few who contend that this type of education of top quality should be available only to those who can afford it. Others would modify this position by introducing a system of vouchers which would permit deferral of the cost of education to a later period when earnings would support repayment. In either case the commitment to quality publicly supported education for those who qualify academically could be seriously eroded.

How, then, is the university in America to chart its course through this bewildering complex of sometimes contradictory but always insistent pressures? However hazardous may be the answer and however risky may be the accommodations our universities make with changing times, our centers of higher learning are well advised to try something new, to venture into untried and uncertain arrangements, *for few options are as certain to be as perilous for our universities as the illusion that the status quo is sustainable.*

Financial Condition of Higher Education

Earl Cheit [5, p. 169] finds that both costs and income of institutions of higher education are rising, but costs are rising at a steady or increasing rate whereas income is growing at a declining rate. For most institutions the impact of this pattern appeared in 1967–68 or 1968–69. He points to the period of unprecedented growth of the previous decade as contributing to the vulnerability of institutions to the downturn, four causal factors being undercapitalization, overextension, assumption of new responsibilities without permanent funding, and continuous raising of quality standards. An important part of the cost rise Cheit lays to demands, both external and internal, for research, service, broader access, and academic innovation. On the basis of review of 41 various colleges and universities he concludes that all types of institutions are feeling the financial pressures, with those in urban areas and private research universities most severely affected.

Of the 41 institutions studied, 29 (71 percent) either were headed for financial trouble or were in financial trouble at the time they were reviewed. An institution was judged to be in trouble if any services regarded as a part of the program had to be curtailed or if their quality declined. Those headed for trouble were able to meet current financial responsibilities but either could not ensure that these could be long met

without a reduction in standards or were unable to plan to support evolving program growth. Some might question the criteria and their measurement, but the direction of Cheit's findings are clear.

A National Association of State Universities and Land-Grant Colleges survey [11] reports that 69 of 78 universities responding have introduced measures to cope with rising costs. Forty-four are deferring maintenance costs, an easily adopted economy in the short run with ominous longer-run implications. New programs are being eliminated at 42 institutions, while 40 have introduced faculty-staff freezes and cutbacks.

Chambers [4] reports that the rate of growth of state support for higher education appears to be slowing, citing final action taken by 20 state legislatures in mid-1971 in appropriating operating funds. In the 20 states a growth of 26 percent for the two-year period 1969–70 to 1971–72 compares with that of 35.5 percent between 1968–69 and 1970–71. Several state budgets subsequently passed, including California's, will significantly widen this gap. While valid as gross comparisons, these data tend to sharply underestimate the impact of curtailed appropriations on academic programs. Sharp rises in nondeferrable fixed costs as a result of inflation typically are early and large claimants on any budgetary increases. Most institutions have given top priority to salary increases for faculty and staff as a means of retention for the longer run, but such action inflates the real worth of reported increases in appropriations for current operations. Increased salaries of faculty and staff in colleges and universities, a major cost component, tend to translate directly into increased costs per student since there is little if any offset from productivity increase.

Private schools, whose revenues come largely from tuition and fee income, federal government, gifts and grants, and income earned on endowments, have increased tuitions to meet rising costs and to offset declines in the other revenue sources. Though the empirical evidence is scant, indications are that income for both public and private institutions will rise at a rate inadequate to meet prudent levels of operation and that this condition may continue for several years [5, pp. 111–118].

Legislative action on college and university budgets for public higher education in recent years suggests a general disbelief that the quality of higher education will be seriously affected by enacting budgets well below requested needs. The ability of institutions to adjust to lower per student appropriations has given some credence to this view in the early stages of financial stringency, but this cannot continue. Further, legislative attitudes and actions in appropriating funds suggest growing concern with institutional performance, and a desire to strengthen control through the budget process is reflected in budget control language that challenges the integrity of the institutions in their allocative decisions, in legislated faculty workloads, and in enforced increases in student-faculty ratios. Such actions have been punitively motivated in isolated cases. But they reflect primarily extensive frustration at an inability to quantitatively assess the process and product of higher education, unhappiness at the understandable lack of cooperation and ability of institutions to assist in the process, and an overriding pressure from other claimants on public funds.

Concerns at the federal level are less clearly articulated, but the rising federal interest in specific program areas such as the health sciences and the growing pressure for institutional support from federal sources has heightened interest substantially. Members of congressional committees responsible for programs and appropriations relating to higher education are openly critical of the pace of reform in higher education. Any major institutional aid forthcoming may well require the recipients to give evidence of updating the educational process as the price for assistance.

In short, the financial picture for higher education, both public and private, is not bright and is not likely to change for several years. Kerr [9, p. xiii] suggests that if average annual educational cost increases per student can equal three percent per year more than the general rise in the cost of living, educational quality can be maintained. He is convinced that cost increases can be held to that level and that if they are the nation can afford to provide sufficient funds to finance future expansion of higher education.

Institutional Responses

Four major thrusts in institutional change were emerging prior to the onset of serious financial concerns. By far the strongest was for improved educational experiences for undergraduate students. Rooted partly in an apparent breakdown in articulation between high schools and universities and partly in the gradual shift in professorial resources from undergraduate teaching to graduate instruction and research, a strong

student-led movement developed for: greater flexibility in curricula requirements; broader course selection, including offerings in a broad range of current issues; increased individual study and tutorial instruction; and elimination of course requirements that substantially duplicated previous high school study. Requests for more opportunity to interrupt formal on-campus programs with off-campus work and study reflected a strong desire to bridge the gap between the lecture hall and laboratory and the real world. Each of these proposed changes struck hard at the traditional structured education carefully meted out in measured and largely independent parcels, with satisfactory completion defined in terms of specified units and courses. Not clearly articulated at the outset, but quickly to become a central issue, was the obvious demand on the faculty for a larger share of its time to be devoted to the undergraduate.

In belated response many institutions began an agonizing reappraisal of course offerings and curricular and graduation requirements, but conventional resource allocation procedures to departments based predominately on instructional workload provide a strong barrier to change. In some institutions where faculty have extensive authority for academic decisions involving the instructional programs, inducing objective review, let alone motivating constructive revision, has challenged the ingenuity of those who have resource acquisition and allocation responsibilities. Change can be induced, but increased faculty resources are invariably requested. As institutions have attempted to respond positively, tight budgets have all but closed this option to induce change. Budgetary incentives have thus become almost totally negative in the academic view but at the same time may become a more positive force in bringing about important revisions in the educational process.

A second thrust was the strong commitment on the part of the faculty, students, and administration to increase the availability of higher education to the economically disadvantaged and to alter the ethnic mix so as to more nearly approximate that of the total population. Massive support for student aid, tutorial assistance, recruitment, and counseling were required. With extensive federal assistance many institutions have accomplished much in this field, although such programs are by no means popular with all segments of the public, particularly where enrollment ceilings result in direct substitution of one group of students for another. Additional state appropriations for these programs have been difficult to obtain.

A related attempt to make available higher education's resources to a broader public are the extended university or continuing education programs. Some resistance is encountered internally based partly on fear of the erosion of academic standards and partly on workload implications. Administrators see an opportunity to touch a broader public, thus increasing understanding and support for the institution, but fear the possibility of diluting limited resources. Public responsibility for supporting these programs has not been universally accepted.

A third thrust rapidly gaining momentum has been the expansion of professional programs, particularly in health sciences, law, and administration. Of greatest *institutional* impact has been the expansion of health science programs, because of their high costs, both operating and capital.

The fourth thrust has been renewed interest in problem-solving research dealing particularly with social problems in America. Those who have chosen to enter this field are discovering that when outside interest is aroused, expectations of widely applicable results are high in some quarters, the research is difficult to accomplish, and the political interests are invariably felt both by the individual and his institution.

Each of these areas of development has been approached, both by those directly participating and those responsible for acquiring those resources, as if additional resources were or could be made available. Thus most institutions committed themselves to one or more major improvements at the time budgetary stress appeared. Early responses to financial stress reflected a commitment to keep existing and improved programs intact and to reduce in such areas as plant maintenance, student services, equipment and travel, cultural enrichment programs, and numbers of staff employees. As the financial support has fallen further behind, many institutions now face the painful task of setting priorities on academic programs and examining program productivity. In retrospect, it is unfortunate that these steps were not taken earlier when the need was first recognized and the resources to assist in the adjustment process were more plentiful.

Academic review, after nearly 20 years of uninterrupted growth and given the historical division of authority and responsibility for academic programs between faculty, administration, and governing body, must address itself now not only

to substance but also to process. Process can be disposed of in general terms, for no prescription will fit the needs of all institutions. A variety of discipline-oriented review bodies can be established with membership drawn from within and without—from faculty, administration, students, and persons outside the academic community. But success depends on the existence of operationally defined objectives against which programs can be assessed; on participation of those directly involved in preliminary review and analysis of their programs; on prior understanding as to whom recommendations for change are to be made; on how and by whom plans for change are to be formulated and executed; and on how appeals are to be made.

With respect to substance, major sources of weakness are in programs that have grown obsolete in terms of needs; those in which student interest has waned but which should be retained in a quality university; those for which resource allocations are excessive; those in which degree production per student enrolled is very low (particularly in graduate programs); and those that involve very large resource commitments and for which excess capacity exists either elsewhere on the same campus, on another campus in a multicampus system, or at another university in the vicinity. No single criterion such as student enrollment, degree production, or any other common measure provides an acceptable answer, although external pressure for applying simplistic criteria across campus and disciplinary boundaries is ever present. In short, additional specialization in our institutions may well evolve, particularly at the graduate level in multicampus systems—a move that economists would find difficult to fault. Specialization in graduate education has long existed, but entry into graduate work by many colleges and universities in the last two decades has probably resulted in excess capacity.

Several major graduate degree-granting institutions have made or are considering significant reductions in graduate enrollments. If the quality of students admitted to these institutions rises and budgetary constraints force students to meet their program objectives in a shorter period of time, productivity in graduate education can increase markedly. At the same time more resources can be freed for meeting legitimate changes in undergraduate education. While difficult for some to accept, these changes, accelerated by more stringent budgets, are in the best long-run interests of our colleges and universities. This is not to argue that graduate study should be downgraded, but rather that too many programs of less than top quality exist, and in the better programs less time and resources need be consumed by staff and student alike in producing highly capable graduates. The same can be said for many undergraduate programs as well.

A persistent criticism is made against major universities that the distribution of faculty time among teaching, research, and service has become unbalanced in favor of research. External pressure for heavier teaching loads and internal demands for more of the faculty's time for the students will undoubtedly leave their effect over time, although the availability of outside funding for research and the promotion practices of the more distinguished institutions are strong deterrents to any major redressing of the balance on these campuses. Historically, the pace of discovery in science, the rate of its transfer into new technology and the magnitude and rate of institutional and social change in this country were all substantially less than they are today. Those training for academic employment developed specialties and subspecialties as knowledge expanded. During the period of rapid development of new fields, unprecedented growth in resources allocated to higher education allowed colleges and universities not only to keep abreast in new areas but to lead the way in most.

As institutions approach a steady state and new resources become scarce, new fields can be developed only by internal resource transfer. This means eliminating programs that are approaching obsolescence or for some other reasons are of low priority. Financial support can be shifted and space can be renovated to serve new needs with little difficulty, but transfer of human resources is most difficult. Finding the solution to this problem is the key to universities and colleges being able to serve our society efficiently in teaching and research in the future. Unless it is solved we shall experience increasing difficulty in resource acquisition. The solution lies in encouraging and financing academicians in their quest to stay abreast of new fields and rewarding those who are willing to risk mid-career shifts in program or emphasis. The problem can be reduced significantly in some fields if greater emphasis is placed in graduate education on mastery of basic disciplines at the expense of early specialization. Also, much can be accomplished with greater attention given to selection of permanent faculty.

The need for and means of increasing flexibility in faculty resources, are actively being stud-

ied particularly by the larger public institutions whose hiring and tenure policies were geared to growth and resource acquisition roughly commensurate with that growth. Retirement systems with large incentives to continue to full retirement age are being critically examined. Hiring and tenure policies that would allow for a larger portion of the faculty to turn over in any given period of time are under discussion. But for the bulk of the existing faculties positive and effective incentives to shift emphasis or change direction must be found. Extended leaves to retrain, plus an additional program support commitment following the retraining period, may offer a possibility. An institutional investment in the mid-career employee with the potential and desire to shift into a new area will bring excellent returns, particularly if appropriate allowance is made for the cost he represents if he continues as is.

These are the challenges facing higher education generally today. They reflect difficult problems, though not as new as often purported to be, and we are very much later than we should be in confronting them.

The Case of Agriculture

The agricultural sector of public higher education has had a long and distinguished career. Its contributions through research to the growth and well-being of the nation have been documented; those from instruction and public service are less well documented but widely accepted.

For over a decade individuals in the land-grant colleges have been calling on their colleagues to reexamine their program commitments within a broader framework [8; 15]. They pointed to the merging of what were historically agricultural problems with those of the rest of American society and the merging of values of urban and rural America. There was a growing recognition that the resources of the agricultural colleges and experiment stations could be more productively engaged if a greater portion were allocated to solving problems related to consumption, human development, and resource quality and management. Implicit in this view was a shift of resources away from such traditional areas as plant and animal production and protection. At the same time many of the more imaginative and better-trained persons in the traditional fields, supported partially with grant funds, have moved into more basic research areas.

It is frequently assumed that the problem-solving approach and technical skills of agricultural scientists are readily adaptable to broader problems. Results have been mixed, ranging from little more than broadening the name of the college to establishing one or more interdisciplinary departments involving scientists from other schools and colleges in joint teaching, research, and service activities. Where serious buildup in the social science fields has taken place, the record of accomplishment is also mixed. With the backing of the Kellogg Foundation and the Farm Foundation, outstanding public affairs programs have developed, particularly in Iowa and North Carolina. But many who have engaged in research on current social problems have encountered greater difficulty than anticipated in conducting research and have found that political considerations frequently overshadow all others.

Since growth in agricultural colleges has been far below that experienced by other sectors on campus, few new resources, except for replacements, have been added. Therefore changes in direction have had to be largely internally generated. While somewhat more difficult to achieve, the record in agriculture may be somewhat better than in other programs because of the earlier and somewhat greater pressures exerted for change. Departmental tradition is still a formidable barrier to program broadening, however, in nearly all institutions and fields.

Each of the three colleges of agriculture in the University of California system has moved in its own direction. At Berkeley emphasis is shifting toward resources and environmental concerns; at Davis programs in applied behavioral science, fish and wildlife biology, and ecology have emerged within the renamed College of Agricultural and Environmental Sciences; and at Riverside a marriage with the biological sciences has produced a College of Biological and Agricultural Sciences.

Urban-dominated legislatures have become increasingly critical of state expenditures for agricultural research in the past few years and cuts in research budgets have been frequent. In the absence of more convincing justifications, colleges and experiment stations will have to look increasingly to private and federal sources if they are to maintain their levels of activity.

Agricultural economists have clearly demonstrated a growing commitment and ability to shift emphasis to a wide variety of problems in such diverse fields as recreational resource development, unemployment in rural-urban communities, distribution of public services, tax policies, and even institutional reform per se [12; 14; 1]. Ways must be found to insure support for these

programs, in the face of anticipated further reduction in agricultural research budgets, until evidence of this shift in emphasis can develop more fully.

Some Strategies for the Future

During periods characterized by exceptional uncertainty, it may appear presumptuous to discuss strategies for the future. Yet for higher education the need for a positive strategy has not been greater in our time. I have selected four issues which, depending on the path chosen, will influence markedly the future course of higher education for the next several years favorably or unfavorably: (1) what internal reforms we choose to achieve and our effectiveness in achieving them; (2) how we relate to and interact with the American public, whether we are public or private institutions; (3) how we relate to the federal government, particularly with respect to funding; and (4) how we go about protecting our institutional integrity in the changing period ahead. This list is certainly not all-inclusive, nor can the issues be as clearly isolated and dealt with separately as this presentation implies.

I have discussed some specific reforms now being considered in higher education, but two fundamental changes must be made in our institutions if their ability to serve our society is to be retained and strengthened.

First, a *strategy for planned flexibility* must be developed and set in motion. Quantitative estimates of future growth are subject to major uncertainties, and we must be in position to adapt to marked changes in enrollments at all levels on relatively short notice. Strategies will differ for individual campuses, whether they are independent or members of coordinated systems. Equally important is the need for a strategy that enhances programmatic flexibility, especially for steady state campuses in periods of stringent budgets. Barriers to flexibility are largely organizationally developed and protected. The task is to gain flexibility without destroying the positive contributions and the security provided by departmental and college structures.

Second, educational institutions must develop aggressive strategies to increase productivity of the human element in the educational process. Steps are being taken to loosen formal requirements for students, but the productivity of the educational process has changed little. Condemnation is inappropriate, for the task of increasing educational quality during decades of unparalleled growth has been enormous. But it appears that we are entering a new phase in which increased attention is focusing on the productivity of resources allocated to higher education, particularly the human resources, both teachers and students. I concur with the view advanced by Schultz [13, p. 332] that the possibilities of economizing on the labor entering education "are mainly to be had by many small innovative reorganizations of the instructional interplay between teachers and students that will reduce the time spent by each in achieving a given educational product" rather than predominantly in adoption of technology.

Effective strategies in these two areas will depend heavily on an institution's ability to develop and adopt a style of academic planning that clearly points direction yet is flexible and responsive to new circumstances, that provides administrators with information that will assist in reaching intelligent decisions, that clearly allows for broad participation and review without undue sacrifice in timeliness, and that can be readily understood and supported by those who must advance the cause of higher education in state and federal government. To my knowledge no institution has approached this utopian goal but many are struggling valiantly.

Internal practices for allocating resources in line with accepted planning goals must be carefully established and constantly monitored to assure that hidden incentives do not yield unwanted results. Classical formula budgeting, while more easily administered and defended, tends to project the past forward instead of being a positive element in helping to achieve the strategy adopted.

With respect to the general public, higher education has suffered a series of mishaps, creating a confidence crisis that must be corrected. This requires far more than a popular "public relations" approach. First, it requires a faculty and administration commitment to expend whatever energy is required to bring about a broadly based understanding of what higher education contributes to the well-being of those it serves, those to whom it is responsible, and those to whom it looks for support. Above all we must succeed in restoring public perspective with respect to what happens on campuses today and what will be happening tomorrow. The inward-looking strategy of the past is not acceptable in the decade ahead. Nor can institutions rely solely on alumni, political leadership, or national educational organizations to advance their cause. Granted, this is unfamiliar ground for faculty and many administrators,

but its cultivation will bring excellent returns.

These actions will be particularly effective for publicly supported universities when backed by a strong public service program, a record of problem-solving research matching in quality the university's contributions in the development of new knowledge, and a well-developed continuing education program serving the professions *and* those eligible to participate in university-level programs but who are unable to engage in full-time residential study.

The relations between higher education and the federal government will take on new dimensions in the next decade. Greater financial participation is almost certain, given the federal interest in higher education, the resources required, and the comparative taxing power of different levels of government. Public and private institutions alike can expect to participate. Higher education must adopt a strategy that, among other attributes, marshals the information available and provides additional evidence on the costs and benefits of higher education and the appropriate federal role in its support. Economists have contributed substantially, but more must be done to translate concepts and models into empirical evidence [6, 16].

Three types of federal support are of particular interest in the period ahead. Student aid represents a national commitment to broadening educational opportunity. Institutions are making heavy supporting commitments both educationally and financially, and expectations among potential students otherwise unable to attend college continue to rise. Though the ground rules may change from time to time, this commitment must continue at a high level and should expand over time. Collectively and individually colleges and universities must keep the importance and dimensions of this undertaking before congressional and executive branches of the government.

Expansion of student opportunity has led to increased interest in institutional aid. While the form is not determined, further assistance is to be anticipated. Of utmost importance to public institutions particularly is the inclusion of effective maintenance-of-effort provisions. These must allow for inflation as well as growth in numbers to preclude offsetting withdrawal of support from state sources.

If the federal goals for expansion of specialized skills, particularly in the health sciences, are to be achieved federal support both for capital outlay and operating expenses are an absolute necessity, though I am not convinced that historical per capita outlays in real terms are required. Even if substantial internal reallocations were to take place (a move guaranteed to create student as well as faculty discord) few institutions can expand significantly the output of doctors, dentists, veterinarians, and other health science professionals without additional public funding.

Finally, to the question of institutional integrity. Pressures largely from outside, but reinforced from within, are tending to place more controls on the academic community. As a result the balance of power is threatened, with faculty autonomy most directly challenged. Some realignment is to be expected as institutions move more centrally into the life of the community, state, and nation. It is none too early for each institution to assess the impact of its growing involvement and to institute plans to protect its control over its own affairs insofar as it can. Private universities and those constitutionally protected have some advantage over those more directly subject to outside interference. In either case, strategy designed to build an atmosphere of confidence and trust should be instituted, for resort to legal defense under constitutional protection is of questionable long-run interest to those so protected.

Governing boards, however selected, have an obligation to protect and represent the interests of the institutions they govern. The way members are selected and the length of terms influence greatly how well this obligation is met. While such matters are largely out of the hands of the institutions themselves, at this juncture it is imperative that any proposed changes in governance be thoroughly examined and implications made known. Any changes that further erode institutional integrity would weaken markedly the ability of institutions to serve society in the objective manner in which our universities and colleges were conceived and nurtured. Any changes that provide more effective buffers against potential partisan influence should be strongly supported.

I opened this presentation with a familiar and appropriate quotation from Francis Bacon, "Adversity is not without comforts and hopes." It is my hope that adversity has not destroyed the objectivity essential to this commentary on the state of higher education today. I can assure you that the lack of comfort is partially offset by hopes—hopes that are materially strengthened by the realization that we have more control over our institutional destinies than we think we have. The decision we must make is simply whether we in higher education will lead or whether we are prepared to accept the leadership of others.

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INVITED LECTURE

The Quest for Relevance in Agricultural Economics*

GLENN L. JOHNSON

OUR knowledge-producing and teaching institutions are under sharp criticism and pressure. Many students question whether our universities and nonuniversity research institutions are properly related to the issues and problems of our time. Within faculties and staffs we find some who defend our traditional disciplinary organizations and others who would drastically reshape them to better handle our problems and issues. Wolfle has recently argued in *Science* [24], I think mistakenly, that the traditional disciplinary department has so outlived its usefulness that it is now time to "honor its achievements with a ceremonial and sentimental retirement party." Similarly, some administrators defend traditional disciplinary structures while others would abandon disciplines in favor of problem-solving, issue-oriented organizations. Individual academicians, staff members, students, and legislators are all uncertain and uneasy. They vacillate between traditional academic interests and efforts to serve society while exerting random, chaotic pressures on administrators [23]. In short, we are in a period of general uneasiness in which our entire intellectual establishment is under close critical examination.

Agricultural economics, while less bothered with unproductive student disruptions than many other disciplines, is no exception with respect to the thinking of its productive, hard-working students, its faculties, staffs, and administrators. The same conflicting quests for social relevance and disciplinary excellence affect our students, faculties, researchers, extension workers, and administrators.

Recent changes in the list of problems and issues before society have combined with the decline in our agricultural population to cause many U. S. agricultural economists to question the need for agricultural economics. This concern produced Gray's and Firch's delightful allegories [9] in which they liken agricultural economists to blackfooted ferrets, who live on prairie dogs (farmers), and administrators to great-horned owls, who live on both. Gray noted that prairie dogs are being exterminated by the Department of the Interior and that this eliminates the food supply for the blackfooted ferrets, a protected species. Firch and Gray alleged that it is now difficult to identify even one agricultural economist, asserting that the rest have transmogrified themselves into all sorts of other beings because, in part, they have no more agricultural problems to solve. Somewhat similarly, James Shaffer has argued [22] that agricultural economists should transmogrify themselves into applied social scientists and that they should then work on urban as well as rural problems in order to find appropriate and adequate levels of employment. Ernest Grove [10], Samuel Crockett [5] and David Narrie [19] have made some revealing points about relevance, disciplinary irrelevance, and the lack of problem-solving, issue-oriented work on the part of agricultural economists. Other pertinent recent statements by agricultural economists include those of Emery Castle [4], Peter Dorner [6], Dale Hathaway [11], James Bonnen [2], and Clifton Wharton [23]. As opposed to the tendency of departments of agricultural economics and individual agricultural economists to transform to other ways of addressing themselves to the problems of society, there is also a tendency for agricultural economics to revert to general economics in a quest for disciplinary excellence in the traditional departmental structure of the university.

This introduction indicates a need to gain perspective with respect to agricultural economics at this point in time. I propose to do this by looking at:

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1. The general characteristics of the problems and issues before agriculture and rural society which agricultural economics might help solve.
2. The processes of solving these problems.
3. From these examinations of the characteristics of problems and issues and the process of solving them, I shall derive operational guidelines for agricultural economics in the decade ahead.
4. These operational guidelines will have specific implications for teaching, research, extension, administration, and individual agricultural economists.

Some Issues and Problems

Current rural and agrarian issues and problems include but are by no means limited to poverty, problems of minority populations in rural areas, regionally maldistributed populations, unionization of hired farm laborers, lack of individual control over one's destiny,[1] environmental quality problems, impacts of urban renewal development and welfare programs on nonmetropolitan areas, inadequate community services to rural areas, undernutrition in both rural and urban areas, the multitudinous important developmental problems of the LDC's, malfunctions in the private control of resource use and production in U.S. agriculture, and overpopulation, not to mention continuing farm management, agricultural marketing, and agricultural policy problems. As I see it, there is little danger that we shall run out of work to do despite those who feel there is nothing left worth our attention.

Nature of Current Issues and Problems

These issues and problems have several common characteristics which are far more stable through time than the problems and issues themselves. It is the commonality of these characteristics that will permit us to deduce certain guidelines for agricultural economics in the years ahead. Rural and agrarian problems and issues can be characterized as:

(1) Continuously changing.
(2) Practical, not disciplinary.
(3) Multidisciplinary but not interdisciplinary.
(4) Having solutions involving both market and nonmarket adjustments.
(5) So complex that few, if any, of the many disciplines required to handle them have adequate theories, descriptive information, and quantitative techniques.
(6) Individualistic as well as social.
(7) Requiring normative knowledge to reach prescriptions for their solution.

With this as a quick introductory outline, I shall now examine the characteristics of problems and issues in more detail.

An outstanding characteristic of the issues and problems that demand our attention is their *changeability*. Just a moment's historical reflection indicates that such problems and issues have always been with us and that they continuously change. I need only mention the Country Life Commission, Teddy Roosevelt and the conservation movement, the Greenback movement, Upton Sinclair and "the jungle," antitrust investigations, the Grange, the farm board, the great depression, soil conservation, mobilization to produce farm products for World Wars I and II, the Farm Security Administration, the poverty commission, etc., to establish empirically the changing nature of agrarian problems and issues.

I have noted that *these problems and issues are practical, not disciplinary*. The distinction drawn here is between problems of the nonacademic world which private and/or public decision-makers cannot avoid as contrasted with problems of academic disciplines which they can avoid. When a practical problem exists, nonacademic decision-makers have to live with it. Even when they decide not to try to solve it, that is in effect a decision to live with the problem and its consequences. By contrast, a theoretical or descriptive problem may exist for years in an academic discipline such as economics without practical consequences and without pressure from nonacademic decision-makers for its solution. The problems and issues listed above can be seen to be practical from an example. Environmental quality problems are before nonacademic decision-makers, both public and private. If nothing is done about them, they continue and we all live or die with their practical consequences. Thus they contrast sharply with the purely theoretical and descriptive questions of disciplines which have no known practical consequences.[2]

I have also noted that *the problems and issues*

[1] Includes the problem of the concentration of industrial control in agribusiness as well as elsewhere stressed by Shaffer [22].

[2] As soon as a disciplinary concept, theory, or bit of descriptive information has recognized practical consequences, it becomes practical as well as disciplinary and, as such, relevant.

before society are multidisciplinary and not interdisciplinary. By this I mean that information from a multiplicity of disciplines is required to solve the problems and issues that are before society and that information which falls between or among disciplines is inadequate. Generally speaking and over the years the physical science disciplines have been of about equal importance with the social sciences, and there is no evidence that this has changed. Vernon Ruttan in his presidential address [21] illustrated the importance of the physical sciences in solving pollution problems.

By a discipline I mean a field of study that produces theoretical constructs and descriptive information either because they are thought to be generally useful or to satisfy curiosity. By this definition, fields such as agronomy, animal husbandry, and horticulture can be regarded as disciplines as well as such more fundamental fields as genetics, economics, physics, mathematics, and philosophy.

If interdisciplinary knowledge is different from disciplinary, it must mean bodies of knowledge and investigations that do not fall in any of the generally recognized disciplines but fall instead between or among them. Emery Castle [4] has correctly pointed out that if such bodies of knowledge were significant they would become disciplines themselves; for instance, biochemistry has emerged as a discipline in its own right. Thus, persons who try to have command over the interrelationships among many disciplines without mastering any of the disciplines themselves seldom have command over knowledge of much practical or disciplinary significance. Whether the motivation for seeking such command stems from the problems dealt with or from breadth in interest, three things tend to happen for interdisciplinarians: (1) Their concern with interrelationships among disciplines leads to shallowness in their command of specific disciplines; (2) both their interdisciplinary knowledge and their mix of commands over specific disciplines seldom remain appropriate to the changing sequence of problems and issues before society; or (3) they create a new discipline such as biochemistry.

Let me illustrate the differences between the interdisciplinary and multidisciplinary from work on rural development problems in Nigeria [13]. This work drew on personnel from many disciplines—economics, sociology, zoology, botany, genetics, and such applied disciplines as dairy husbandry, animal husbandry, nutrition, soil science, and veterinary science. It did not involve a need for interdisciplinarians *specialized* in the interrelationships between and among disciplines. When a geneticist or plant breeder was needed, the very best was required (a Borloug or a Sprague) in full command of the heart of his discipline. When an economist was needed, we required one who knew the theoretical and descriptive subject matter of economics and was prepared to modify old theory and to develop new theory and descriptive information to handle the problems at hand. The same was true with sociologists, veterinarians, and animal husbandry men. There was a shortage of people with adequate command over the hard-core concepts, descriptive information, and quantitative techniques from the very hearts of the different disciplines involved in each particular problem but no shortage of interdisciplinarians; in fact, interdisciplinarians were in oversupply relative to their low productivity![8]

It is characteristic of the problems and issues facing agricultural economics that *their solutions involve both market and nonmarket adjustments*. Initially the possibility of solving, say, a pollution problem with market adjustments is not great. Ordinarily the market has gone about as far as it can go toward solving pollution problems without assistance in the form of nonmarket adjustments. Typically consumers and producers have not made the required changes because of costs and benefits external to their private calculations. We note and stress, however, that nonmarket adjustments to internalize previously externalized costs and benefits automatically throw the market into a disequilibrium which leads in turn to market adjustments. Thus devising, designing, and instituting both market and nonmarket solutions to our problems require full command over the *disciplinary economic theory* of market adjustments.

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[8] It should be noted that many people have hard-core disciplinary skills and knowledge from more than one discipline. Common combinations include economics along with such second disciplines as statistics, a technical agricultural science, mathematics, and sociology. Multidisciplinarians have disciplinary command over the hard core of their disciplines, as contrasted with interdisciplinarians who *concentrate* on the interrelationships among and between disciplines; as such, multidisciplinarians can provide such command to problem-solving teams requiring such disciplinary skills to solve the problems to which they address themselves, whereas interdisciplinarians cannot. It must be noted that the number of disciplines one person can command is much smaller than required for most practical problems and that the required combinations of disciplines vary widely from problem to problem.

Another characteristic of the problems and issues before our society is that *they are so complex that the demands they place upon our disciplinary concepts, information, and quantitative techniques exceed the present capacities of our disciplines.* Almost without exception the real world practical problems and issues that we have mentioned remain unsolved in part because of disciplinary inadequacies. For instance, at my own university we are working on a major practical problem of purifying and recycling water from the sewage disposal system into the natural underground water system for reuse. The chemical, physical, and biological theories, concepts, and information available to design and operate such a system are inadequate. In this connection earlier work on fertilizer rate application problems done cooperatively by economists and soil scientists provides interesting insights. When first starting this work, production economists thought that agronomists possessed the necessary chemical, physical, and biological concepts and descriptive information. All that was needed, we thought, was some simple economic theory, appropriate experimental designs, and the application of well-known econometric techniques. However, it soon became painfully clear that the concepts of soil chemistry, soil physics, and soil biology were inadequate. Further, measurement techniques were so lacking that the supply of nitrogen in the soil could not be measured with any degree of accuracy. Also, our economic theories as well as the experimental designs offered by the statisticians and biometricians were woefully deficient. Though we lack sufficient disciplinary information to handle fertilizer rate experiments dealing with only a few cubic feet of soil in the top two or three feet of small plots, the MSU project for recycling sewage effluent involves cubic miles of earth and an even larger volume of atmosphere. Thus, the complexity of the recycling problem simply exceeds our extant chemical, physical, and biological knowledge. And when we turn to the economics side of it we find that the task of evaluating the necessary public and private investments and disinvestments also exceeds our disciplinary capacity. For instance, such modern books as Ferguson [7] and Naylor and Vernon [20] and such older books as Sune Carlson [3] are all deficient with respect to investment and disinvestment theory.[4] Other current problems and issues also exceed the capacities of our disciplines.

This is not the place nor is there time to enumerate and document all of the other disciplinary shortcomings of economics revealed by past work on problems and issues; however, there is time to call attention to one more major deficiency in doing practical research on the agricultural problems and issues of our times. The maximizing theories we are so wont to use are based upon four requirements, all of which are seldom met in dealing with the nonmarket aspects of the problems and issues under discussion. First, before we can maximize we must have an objective function —a normative common denominator. It must be possible to add the various "bads" together and subtract them from the sum of the various "goods" in order to define a single objective function to maximize. In general, the objective function must deal with goods and bads for both individuals and groups. Far too often we perjure ourselves by assuming that we have a common denominator when we do not.

The second requirement is particularly important in the case of nonmarket adjustments: that the common denominator or objective function have interpersonal validity. If the common denominator does not, we cannot arrive at solutions to those major problems and issues, such as poverty and racism, whose solutions require the redistribution of property (rights and privileges) ownership among people. This is the problem discussed by Horvath [12].

The *third* requirement is implicitly recognized by our use of the laws of diminishing productivity and utility. These two laws establish the second-order conditions mathematically necessary for the existence of the optima we seek as bases for prescribing right as opposed to wrong actions [17]. When we design programs to introduce technological, human, and institutional changes, there is no automatic guarantee that anything like the laws of diminishing returns and utility hold. Not, at least, until much prior investigation of the type suggested by Vernon Ruttan [21]

[4] Some of them touch on investment. None of them distinguishes carefully between investment costs and salvage or disinvestment values. Opportunity costs, if mentioned (and they are not in Ferguson's book!), are not related to investment costs and salvage values. More fundamentally, the economics of deciding how much service to extract from fixed durables is inadequately handled. This, of course, is the user cost problem which was opened up by John Maynard Keynes [15] and discussed but not solved by Arthur Lewis [16]. As long as user cost theory is inadequately handled, the theory of investment and disinvestment in major physical facilities for recycling and utilizing sewage wastes will not be well understood.

has been carried out to rank alternative projects, programs, and policies in order of their decreasing net advantage per dollar spent or per sacrificed unit of some nonmonetary value. In economics we commonly employ the decision rule of simply maximizing the difference between good and bad in order to define a right action. Under imperfect knowledge this is not necessarily the appropriate decision-making rule. There are a large number of possible alternative rules including minimaxing, satisficing, maximization of the present value of expected future net returns, etc.

Our fourth requirement, then, is that we have objective agreement on a decision rule. This is a fundamental problem of institutional economics. What I am really saying here is that economics is woefully deficient in theory to guide what I have recently started calling premaximization work. Most of our present theories are for use *after* we have met the conditions for maximization. Yet the problems and issues we have faced historically and face now demand that we spend a very large portion of our time (1) finding interpersonally valid common denominators; (2) establishing optimal orders in which to take the different steps required to implement alternative projects, programs, and policies; and (3) finding an appropriate decision-making rule to use.

Before leaving this discussion of the inadequacies of our physical and social science disciplines we should note and agree with Chester McCorkle [18] that these inadequacies have already created a credibility gap for us with students and the public. Our inadequate biological, physical, economic, political, sociological theories, descriptive information, and quantitative techniques make the public skeptical of our pronouncements on such practical issues as DDT, the SST, minority rights, welfare assistance, phosphate detergents, and mercury contamination. I believe that decision-makers, students, legislators, and the public at large sense the underlying disciplinary deficiencies of the solutions we offer. Closing this credibility gap (regardless of how the gap is conceived by the public) requires disciplinary progress and the maintenance of disciplinary excellence. When the use of logic and appeal to experience are discredited people begin to reach conclusions emotionally and in an unobjective, inaccurate way [8]. As some of the young people put it these days, they "feel it in their guts." Guts were made for digesting food, not for thinking and observing. We have brains with which to reason and senses with which to observe, and we should not discredit them by using inadequate normative and positive theories and erroneous descriptive information to incorrectly interpret sense impressions while failing to learn and develop more appropriate theories and better information. Disciplinary excellence is a necessary ingredient of problem-solving, issue-oriented work. We must protect, develop, and teach disciplinary excellence if we are to be effective problem-solvers. More specifically, as economists we are responsible for learning, improving, and teaching the logic or theory, quantitative techniques, and basic descriptive information of our discipline.

The problems and issues under discussion typically *involve the interests of both individuals and groups* in a manner not adequately or fully reflected in the distinction between market and nonmarket adjustments. Not all individual values can be satisfied by private adjustments in the market; indeed, fundamental institutional reforms and redistributions of the ownership of the means of producing income are often required before individuals can attain their values in the market place. Conversely, group or collective values are attainable through the market as well as through nonmarket adjustments. Market and nonmarket adjustments, however, are only part of the total process of solving many problems. Underneath are both the individual and group (or collective) values sought in making adjustments. We encounter the difference between individual and group values when we deal with the goodness of self-identification, the badness of alienation, and the goodness of group identity. We need only think of the problems of racial minorities, of ADC mothers, of the aged poor rural whites, and of agricultural labor unionization to begin to see the important distinction. We must consider both individuals and groups as *basic units in our society* in designing institutional, technological, and human alternatives to solve many of the problems and issues of our times. Thus, we are required to have a philosophic orientation that permits us to address ourselves to the identities of both individuals and groups.[5]

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[5] Adding sociology and psychology to the curriculum is not enough. Both sociology and psychology, for instance, can be so positivistically oriented that no objective attention is paid to the values, hopes, and aspirations of either individuals or groups. Economics, too, can be unduly positivistic; however, it has been and can be normatively productive. Adam Smith, J. S. Mill, and Jeremy Bentham are classicists for philosophic value theorists as well as for economists. Modern-day price and welfare theory is normative. Kenneth Arrow's modern book on individual preferences and social choices

The last characteristic to be discussed of the practical problems and issues before the decision-making units of our society is that ***their solutions take the form of prescriptions as to what it is "right to do"*** [17]. Prescriptive knowledge contrasts with normative and positivistic knowledge by being dependent upon both of them.[6] Disciplines such as chemistry and physics produce positivistic knowledge which describes the world in a neutral way having little directly to do with good and bad. Conversely, other disciplines such as ethics and economics produce normative knowledge—knowledge about goodness and badness per se. Alone neither positivistic nor normative knowledge indicates which action is right or wrong to select as a goal or to do. A prescription as to what is right to do depends upon both (1) positivistic descriptions of what has, is, and can be if so and so is done, and (2) descriptions of goodness and badness that provide performance criteria—"objective functions"—for decisions. As soon as we realize that solutions for the issues and problems are prescriptive knowledge, we have to insist that our philosophic orientation be broad enough to include prescriptive work.[7]

promises to become classical in both economics and philosophy [1].

[6] Pragmatism, in making normative and positivistic knowledge interdependent, really limits knowledge (as I view pragmatism) to the prescriptive. As such pragmatism is intolerant of both normativistic and positivistic dogmas, a view that I share and apply to prescriptive knowledge as well.

[7] Among the philosophies, ***pragmatism*** concentrates specifically on prescriptions; it regards positivistic and normative knowledge as interdependent and not separately knowable. By contrast, ***positivism***, which asserts the unobjectivity of normative knowledge, is disqualified. A thorough-going positivist cannot objectively conceive of defining a practical problem, let alone prescribing its solution. The productivity and respectability of positivism in the physical sciences have caused certain social scientists to "ape it." Such attempts have, however, tended to sterilize social scientists by reducing their ability to define and solve problems. As a consequence, some of the positivistically inclined social scientists have taken the intermediate position (*conditional normativism*) of *assuming* answers to normative questions and then defining problems and reaching prescriptive solutions without the benefit of objective empirical work on normative questions. Because, despite their shortcomings, all three of these positions have demonstrated their usefulness in tackling problems and issues, it would seem a wise course for us to insist that none of the three be eliminated from our philosophic orientation but that none of the three be permitted to restrain us from exploiting the advantages of the other two. *Existentialism* is another important philosophy so long as group interests are not forgotten and if existentialism's emphasis on establishing individual identity is not perverted into something that rejects logical analysis and experience in reaching prescriptive conclusions. The individual is important but we don't "gotta be me what else can I be," as the popular song says, ***without regard to logic and experience***. It is also important that our philosophic orientation permit us to consider group values, aspirations, incentives, and hopes.

General Orientational and Specific Guidelines for Agricultural Economics

We have seen that the problems and issues of society change continuously and that hence the problems themselves are not stable enough to yield organizational guidelines for our work. The characteristics of agricultural problems and issues, however, are quite stable and lead to the following seven orientational guidelines for agricultural economics in the decade ahead. First, we need to be able to mobilize hard-core knowledge from the particular combination of disciplines appropriate to the practical problem or issue at hand. Second, we need to remain flexible with respect to the combinations of disciplinary skills and knowledge that we can bring to bear. Third, we need to have skills and knowledge from the normative as well as positive disciplines. Fourth, we need to be able to work with the problems and issues faced by both individuals and collectivities of people such as families, social organizations, government units, producer and consumer organizations, etc. Fifth, we need to work on nonmarket adjustments in full recognition that (a) initially at least the preconditions for application of maximizing theories are not met and hence that (b) much premaximization work including close pragmatic interaction with nonacademic decision-makers will be required. Sixth, we need to develop improved disciplinary ***skills***. Seventh, we need to further develop disciplinary *knowledge*, both theoretical and descriptive.

As these seven guidelines are stated in general, we still need to examine their specific implications for (1) teaching; (2) research, both practical and disciplinary; (3) extension; (4) administration of problem-solving, issue-oriented programs; and (5) individual agricultural economists.

Implications for the teaching of agricultural economics

The crucial agricultural problems and issues before our society make it desirable for agricultural economics teaching to be oriented to these problems and to appropriate approaches for solving them. Solving these problems also requires disciplinary excellence. For the most part, this

means both (1) learning experiences with or in multidisciplinary, problem-solving studies - and efforts and (2) hard-core disciplinary training in economic theory and quantitative techniques. At the undergraduate level, field trips, special problems, and special course programs can provide the necessary practical experience. Most practical issue-oriented undergraduate courses such as farm management, marketing, policy, cooperation, etc., should be taught on a multidisciplinary level and, as such, require administrative support at college and/or university levels. At the graduate level, a wonderful opportunity for practical experience has always existed with respect to dissertation efforts. As agricultural economics is relatively well financed, dissertation efforts can be part of multidisciplinary projects that give the student interested in working on problems and issues exactly the kind of experience he needs. Descriptive information relevant to current problems and issues should be taught at both graduate and undergraduate levels. It must be stressed, however, that problems and issues change and that issue-oriented teaching programs and practical dissertation research must be continually adjusted to the changing pattern of problems and issues.

Our examination of problems and problem-solving processes also indicated a basic need for the disciplinary content of economics. The challenge here is to teach theory, quantitative techniques, and disciplinary data in an inspirational way without becoming superficial. The complementary relationship between problem-solving and disciplinary concepts and techniques is to be exploited without dilution of disciplinary excellence while refraining from disciplinary irrelevance. In my opinion, interdisciplinary and pseudo-disciplinary subjects generally contribute little to either disciplinary excellence or to problem solving, particularly when taught as if they have lasting theoretical and fundamental descriptive content. By contrast, properly focused multidisciplinary courses can provide meaningful problem-solving, issue-oriented experiences.

Still on the disciplinary side, full attention needs to be given in *both* undergraduate and graduate teaching to the assumptions underlying the maximization theories, models, and techniques of economics to insure that they are (1) fully used as appropriate and (2) not used in lieu of less elegant but more appropriate premaximization approaches. As a high proportion of undergraduates have practical career objectives, this is particularly important for them.

Philosophically, our undergraduate and our graduate teaching should be such that our students will be free, and will find it respectable, to work as economists on values, objectives, and aspirations both as problem solvers and as disciplinarians. It should also be such that they will be given guidance on how to work with normative questions in an objective way.

We have also seen that the problems and issues are individual as well as group oriented. This requires that our problem-solving and disciplinary teaching have a philosophic orientation which pays attention to individuals as well as groups. We cannot insure proper orientation to individual and group values by simply including psychology and sociology in the curriculum. These disciplines, like economics, can suffer from philosophic orientations that restrict capacity to work with the normative, either individually or collectively. And just as it is important to consider both the individual and group, so it is also important to consider the interactions between the two. In one sense the history of human societies is one of balancing the interest of groups against those of individuals. And current issues and problems are no exception. There is a relevant economics of groups as well as of individuals to be taught [1].

Implications for research

Our general guidelines also have specific implications for disciplinary research and for problem-solving research and investigations. Demand for the disciplinary concepts and quantitative techniques of economics originates in *problem-solving research and investigations*. As members of multidisciplinary, problem-solving teams, agricultural economists are expected to be able to use these theories and techniques in close cooperation with others using fundamental theories and techniques from genetics, sociology, agricultural engineering, law, animal husbandry, psychology, political science, etc. As Ruttan demonstrated [21], economic theories are particularly useful in predicting the consequences of both market and nonmarket adjustments to solve problems and handle issues. Despite the inadequacies to be noted later, economic theories probably provide a better basis for prescribing right actions as solutions to practical problems than theories from other disciplines. Contrary to often expressed popular opinion, economic theory is centrally concerned with nonmonetary as well as with monetary values, the former being as "economic" as

the latter and major concerns of both consumption and welfare economics.

As with teaching, problem-solving, issue-oriented research must have a philosophic foundation permitting objective work on normative questions [14], both individual and group or communal in nature. It is also crucial that normative and prescriptive work be respected and recognized professionally and administratively. I believe that the awards program of this Association has been remiss in this respect and should be modified to give relatively more recognition to practical prescriptive research.

There are also specific implications for *disciplinary research* in economics. In discussing nonmarket adjustments and the inadequacies of economics, I have already noted that current rural and agricultural problems and issues demand improvements in our theoretical concepts, descriptive information, and quantitative techniques. The deficiencies in our discipline revealed by problem-solving research and investigations provide specific priorities for our disciplinary research. Some of the priority areas are: investment-disinvestment theory; stock-flow conversion theory; user-cost concepts; benefit-cost concepts; the relationships between effective demand and production; the generation, saving, and investment of farm-produced capital; dynamic managerial theory; and premaximization concepts to use in establishing the necessary conditions for applying maximization theories. Other important deficiencies involve theories for dealing with the formation of and trade-offs among individual and group values. These and other subjects all need disciplinary research to make our problem-solving efforts and investigations more effective.

Also, our quantitative deficiencies indicate need for a more thorough understanding of the usefulness and advantages of informal, simple, paper-and-pencil projections. These have long been used effectively in doing premaximization work on nonmarket adjustments to solve practical problems and issues. A modern replacement for this time-tested approach is computerized, systems-science, simulation. As this approach is not fully developed, it is a relevant area for disciplinary research in economics as well as in other disciplines.

While we still have difficulties in estimating the parameters of economic functions and sets of simultaneous equations, I believe that we have overemphasized improving such estimates at the expense of failing to improve other more needed estimates and sources of information. In the last 20 years we have also made great efforts to improve maximization computations, particularly modification and refinements of linear programming. I believe that this area of work has also been overemphasized relative to the use of projections, simulations, and premaximization computations. Our quantitative techniques for dealing with normative questions (while probably better developed than in any other discipline, including philosophic value theory) are inadequate and in need of much more disciplinary research.

Implications for extension

In this connection there are a number of points to be made. Fundamentally, there seems to be no real further need to maintain a distinction between problem-solving, issue-oriented research and extension investigations. The distinction excuses researchers, on one hand, from adequate contact with the decision-makers for whom their practical research is being done and excuses extension workers, on the other, from adequate contact with the hard cores of the different disciplines, including economics on which they depend.

It is my observation that the problem orientation of agricultural economics extension has not been as flexible as it should be, though teaching and research are also subject to the same criticism. Historically, extension efforts have concentrated heavily on agricultural production, farm management, and marketing and, more recently, have placed greater emphasis on resource development and policy. Soil conservation, rural poverty, community services, zoning, and land-use planning have tended to be given somewhat peripheral attention. The new agrarian and rural issues of our time are not adequately handled by all of our U.S.-state cooperative extension services nor by the extension services of other countries.

Implications for administration of problem-solving, issue-oriented programs

The general guidelines developed above place a heavy burden on administration by calling simultaneously for (1) *flexibility* in forming multidisciplinary teaching, research, and extension teams appropriate to changing agricultural problems and issues and (2) *preservation* and *strengthening* of disciplinary skills, concepts, theories, information, and quantitative techniques. This implies the preservation of traditional disciplinary departments, despite Wolfle [24]; how-

ever, it also implies the development of other administrative units to handle problem-solving, issue-oriented work. The first is necessary to close the increasingly obvious gap between the expectations of the public, students, and faculties, on one hand, and our handling of the practical problems and issues of our times, on the other. The second is required to maintain and expand the stock of skilled personnel, concepts, theories, and descriptive information required to do the first. In the long run these two requirements are complementary and must both be attained for either to be productive.

As I see it, the problem for administrators originates in part with three *nonadministrative groups,* all of which repeatedly fail to recognize the essential complementarity between disciplinary and problem-solving, issue-oriented efforts. I refer to disciplinarians, to those concerned primarily with agricultural issues and problems, and to interdisciplinarians and pseudo-disciplinarians who neglect both disciplines and practical problems. The credibility gap that the academic and intellectual world faces today results, I believe, in substantial part from the failure of administrators and these three groups to evolve a modus operandi. The three groups have had enough power to keep administrators and administrative units off balance [18, 23] and hence unclear and ambiguous, partly as a result of (1) being staffed by recruits from each of the three groups; (2) seeking student, faculty or staff, and public support from each of the three groups without at first reconciling the conflicts among them; and (3) being required to spend a high proportion of their time on budgets, politics, and personnel recruiting. It has been all too easy for administrators to paint themselves as servants of their staffs and as dependent for their success on the unadministered and unguided performance of the conflicting staff they recruit. Our failure to organize problem-solving, issue-oriented programs justifies student complaints about irrelevance and the absence of connections between academic disciplines and real world problems and issues. We, both as administrators and as those administered, are responsible for correcting the situation.

The multidisciplinary nature of practical problems dictates that the administration of and administrative support for problem-solving, issue-oriented activities be at a point in the administrative command *above* the administration of disciplinary departments. The administration required can be either formal or informal. In universities this means at the college or university level. In the USDA this means above the administrative units dealing with agricultural economics, plant breeding, data collection, forestry, etc. In foundations and other government agencies, it occurs at the program level, not at the level of disciplinary divisions of plant science, agricultural economics, the humanities, agricultural engineering, medicine, etc.

Among the valued colleagues I asked to criticize and review this paper were a number of experienced administrators and perhaps some would-be administrators. Several of them resisted the idea that administration must coordinate problem-solving, issue-oriented programs across college and department lines or, in the case of nonacademic organizations, above the disciplinary level. Some departmental administrators resist placing administrative responsibility for multidisciplinary programs at supra-departmental levels without recognizing that their departments would have to have control over disciplinarians from other departments to function effectively and hence that they themselves would become supra-departmental if they administered such programs. Such departmental administrators fail to realize (1) that they do not have supra-departmental authority and (2) that attempts to get such authority (as departmental chairman) would create jealousy and envy. One colleague even wrote about an earlier draft of this paper that no college president in his right mind would attach to his office a unit for coordinating issue- and problem-oriented research, teaching, and public service across college lines. All I can say is that if the president does not take responsibility for doing this, who can? And if within colleges the deans do not, who can? It is precisely such failures to administer that students, faculties staffs and the public are concerned about. Students and legislators can validly state that we are irrelevant and ineffective when they observe:

(1) Professors and others concentrating on disciplinary interests to the neglect of issue-oriented, problem-solving work.

(2) Administrators failing to coordinate problem-solving issue-oriented work across departmental and college lines.

(3) Faculty, staff members, and even administrators creating institutes, centers, and interdisciplinary programs that neither promote disciplinary progress nor solve problems and issues but instead provide tenured comfortable bureaucratic homes.

Obviously, my conclusions in this regard have

implications for the administration of *agricultural economics teaching*. In order for agricultural economics students to participate in issue-oriented, problem-solving experiences in multidisciplinary teaching programs, it is necessary that such programs *either* have full administrative support at the college or university level *or* be administered at those levels. Higher administrative-level support is needed to (1) guarantee cooperation from other departments and (2) police the administering department lest it subvert the program to its own disciplinary and bureaucratic objectives. Departments should not be permitted to become multidisciplinary in nature, thereby partially duplicating either the college or the university itself. We must also note that when it is necessary to draw on personnel from more than one college, administrative support is needed from higher than the college level, possibly a special administrative branch of the president's office having to do with universitywide teaching programs. If any subadministrative units or projects are established for administering or running multidisciplinary courses and programs, I believe that no tenure should be granted in them so that it will be easier to reallocate the disciplinary resources in them as problems and issues change.

Severe administrative problems arise in connection with *problem-solving research and investigations*. When contributions are required from more than one disciplinary unit within the college of agriculture (or agriculture division of a nonacademic organization), the problem-solving programs need to have the support of the chief agricultural administrator. If a project is used to administer the program, it should not be permanent. The total research program will remain more flexible if no tenure is granted to project members or to the project itself. Personnel tenure should remain with the disciplinary department to permit the "chain or line of command" to reallocate disciplinary resources to new projects to handle the everchanging stream of problems and issues. Furthermore, departmental tenure for project members will impart a needed sense of relevancy to the disciplinarians therein. Similarly, when the multidisciplinary demands of a problem or issue cross college or division lines, administrative support will be needed from someone more powerful than the competing deans or division heads involved. In a university this means the president's office or someone working out of the president's office.

Fortunately, the administrative difficulties associated with doing purely *disciplinary research* are not large. Colleges, universities, and fundamental research agencies are commonly organized along disciplinary lines. This means that most departments of agricultural economics are able to address themselves to disciplinary research projects without serious difficulty. Occasionally problems do arise in the relationship between agricultural economics and general economics or mathematics and statistics. By and large the research budgets of the departments of agricultural economics have been such that they have been able to acquire necessary quantitative and theoretical skills either directly or in cooperative arrangements with the other departments. Another factor reducing the administrative burden for disciplinary research is that much of it can be done by individuals rather than teams. The main difficulty is in keeping disciplinary research relevant, which in turn takes us back to the problems of administering practical research.

Although *agricultural economics extension* is often administered out of the dean's office with tenure maintained at the departmental level, difficulties are still encountered. These often originate in (1) lack of flexibility in adjusting projects to changing problems and issues and (2) failure to develop administrative structures for crossing college lines to mobilize competencies from disciplines in other colleges.

At this point in this paper I have what I believe to be an important general recommendation to make on administration. Our Association has set up and operates awards programs to improve research, teaching, undergraduate debating, and extension. I believe that these programs have had the expected salutary effects. I believe it is time now to do the same thing for administration. And, within administration, I believe we should concentrate on the administration of *multidisciplinary* programs dealing with agricultural and agrarian problems and issues as contrasted with departmental administration. Further, the awards should not go to project or program leaders; instead, they should go to administrators in position to assemble the disciplinary mixes needed to solve practical problems and issues. Such an awards program would have to be sponsored by at least three associations representing different disciplines concerned with agrarian and rural affairs. To this end I recommend that our Association take steps to see whether such an awards program can be established in cooperation with two or three other associations. The awards could be designated for "Distinguished

Public Administration of Multidisciplinary, Issue-Oriented, Problem-Solving Agrarian Programs."

Implications for individuals

Our operational guidelines also have specific implications for individual agricultural economists. Whether of practical or disciplinary inclination, the individual needs to recognize the essential complementarity between disciplinary and problem-solving, issue-oriented activity. Full recognition of this complementarity implies that agricultural economists will refrain from pushing administrators to support either disciplinary or problem-solving, issue-oriented activity at the undue expense of the other. It also implies that they will push for administrative action to organize multidisciplinary teams to tackle current problems and issues. This involves a willingness to be Indians as well as chiefs on such teams and to recognize that the chief may very advantageously be from a different discipline, as economics has no crucial central role to play in problem solving despite often repeated, empire-building assertions by economists on this point. It also involves recognition that such assignments must be for no longer than required to make one's contribution to the solution of each of the everchanging, rapid succession of problems and issues. Multidisciplinary research is also promoted when individual agricultural economists, as Vernon Ruttan has done, take the lead in pointing out constructively how the discipline of economics can contribute to the solution of practical problems and issues [21]. The formation of multidisciplinary teams is also furthered when individual agricultural economists take the lead in identifying and mobilizing support for problem-solving issue-oriented projects. It is too much to expect administrative personnel to carry this burden alone. There are not enough administrators; they often do not have the competencies to organize and execute the project which the sources of support seek; and their contacts with the problems and issues of the nonacademic world are much more limited than those of their much more numerous faculty and/or staff members. Further, regular administrative duties typically prevent administrators from having enough time to design and execute major projects. Problem-solving research is also promoted when individual agricultural economists refrain from organizing and supporting programs, institutes, centers, etc., which purport to solve problems and deal with issues but which, in fact, become personal empires that contribute neither to disciplinary excellence nor to the handling of agrarian problems and issues. Individual agricultural economists should support disciplinary attempts to teach, maintain, expand, and make more relevant our economic concepts, theories, quantitative techniques, and generally useful descriptive data. Philosophically, individual agricultural economists should adopt an orientation that subjects both the normative and positive aspects of prescriptive analysis, as well as prescriptive analyses themselves, to logical analysis and tests of experience and places emphasis on both individual and group or collective problems, issues, and interests.

Summary

In summary, I have argued that agricultural economics has not died just because the problems now faced are different from those of a decade ago. Indeed, to the contrary, we are particularly fortunate as agricultural economists to have the challenge of important, rapidly-changing agrarian and rural problems and issues. Our opportunities are both disciplinary and practical, and our future lies in fully exploiting the complementarity between disciplinary and problem-solving, issue-oriented work. In order to do this we shall have to grant full recognition to problem-solving, issue-oriented work; be flexible in adjusting to changing problems and issues; preserve and extend our disciplinary competencies; and have a philosophic orientation that permits us to work prescriptively. This means working on the normative as well as the positive and on group as well as individual problems and considering nonmarket as well as market changes in seeking adjustments and solutions to prescribe. We need to reorient our teaching, research, extension, administration, and personal commitments to exploit this complementarity while avoiding disciplinary irrelevance and the pitfalls of interdisciplinary and pseudo-disciplinary efforts which neither promote disciplinary progress nor contribute to issue-oriented, problem-solving work. Administration services are crucial in mobilizing and controlling the multidisciplinary teams required to do successful problem-solving, issue-oriented work. Much of the current sense of irrelevance is due to lack of adequate administrative services for such team efforts, the failures being due to both staff and student inadequacies as well as to administrative shortcomings. Thus, I have recommended that our Association join three or four other associations in sponsoring an annual award for "Distinguished Public Administration of

Multidisciplinary, Issue-Oriented, Problem-Solving Agrarian Programs." This award should be reserved for administrators functioning above disciplinary levels in public agencies and should not be given to project leaders and department heads.

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DOMESTIC ISSUES IN RURAL AMERICA

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Rural America and the Grants Economy

JANOS HORVATH

Agriculture's Perplexity: Market and Merit

EVEN cursory acquaintance with rural life will reveal that a substantial part of its economic contacts with the rest of the world do not go through the exchange process. The image of the rugged individualist farmer is often complemented with and superseded by his alter ego who, either benevolently or under duress, will share with other people.

Flashes from history could provide a variety of institutional alternatives. It is not unlikely that unilateral transfers, i.e., grants, preceded exchange transactions. The primitive family could produce at first only enough for subsistence, but with the invention of agriculture production exceeded the bare minimum of life. As soon as some authority got around to taking the surplus away from the cultivator, civilization began. "Urban civilization . . . in its classical phase was based on agriculture and exploitation [i.e., coerced grants]. The farmer grows more than he needs to feed himself; the surplus is taken from him and feeds armies, artisans, priests, and kings. The agricultural surplus is transmuted into art and literature, Parthenons and cathedrals" [6, p. 48]. Evidently at some point in the process exchange appeared, although the terms of trade usually favored the stronger party; i.e., the transaction entailed elements of exchange and elements of tribute. Such remained the dominant social characteristic through the feudal age, both in the king-versus-squire and the squire-versus-serf relationships. In modern times institutionalized transfers have provided the "big push" toward economic development, as illustrated by the enclosure movement in 18th century England and collectivization in the 20th century Soviet Union. Equally, contemporary land reform movements mix exchanges and grants in the hope of creating an optimal inducement mechanism. A recent case study of the exchange-grant controversy is the European Common Market, where varying degrees of special treatment for agriculture within each member country has created a continuing challenge to the stability of economic integration.

Besides the exposure of policy issues, controversies about the overlap of exchange and grant elements in economic transactions have occasionally resulted in lasting contributions to theory. The famous law of comparative advantage, for example, evolved in a Parliamentary debate intended to demonstrate how the repeal of British Corn Laws would advance national prosperity through cessation of institutionalized grants to landlords. There is no need, but it would hardly be possible anyway, to attempt an exhaustive list here. Clearly, we have already encountered a variety of institutional structures and economic processes wherein the role of the grants economy is apparent, be it curative stimulus or pathological retardation. A definition of the concept is now in order.

A Definition of the Grants Economy

In a general sense grants economics identifies bilateral exchange versus unilateral transfer components in the varying admixture of market and nonmarket economic activity. Grant is such a transaction which involves no recompense. A decrease of the donor's net worth and an increase of the donee's net worth signify the occurrence of granting. For example, an outright gift without the expectation of payment, or any kind of favor, is clearly pure 100 percent grant. Alternatively, an exchange of goods, services, or productive factors at unregulated market price or a loan at the prevailing market rate of interest without concessions in repayment conditions contains zero percent grant. These transactions demonstrate the limiting cases. Under scrutiny it becomes evident that a multitude of economic dealings, even many of those that appear to be normal exchange on one hand or unilateral transfers on the other, do in fact embody both exchange and grant elements. So perceived, grants economics offer a new battery of analytical concepts, and policy tools as well.

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The ideas developed by Kenneth Boulding, Martin Pfaff, and a growing group of associates have come to embrace a large family of voluntary grants and coerced tributes (i.e., negative grants) which permeates any system of human society. Thus partially overlapping the exchange economy, which operates by the rule of quid pro quo, the domain of grants economy performs such integrative functions as income redistribution, system maintenance, economic growth, technological advancement, and so on. If applied to the problems of agriculture, the measurement of grants elements, voluntary or coerced, will lay bare a broad variety of issues.[1] Upon learning the size of grant flows, identifying grantors as well as grantees, we shall possess a greater confidence for cutting through the maze of emotion-packed arguments which embrace not only rural America but the whole national and international economy. A grant dollar, voluntary or coerced, open or disguised, tends to exert a higher leverage on the economy than an exchange dollar. In this context, the grants economy functions as a regulator of the exchange economy. To quote Boulding, "Qualitatively this [the grants economy] represents the heart of political economy, because it is precisely at the level of one-way transfers that the political system intervenes in the economic system" [4, 6].

The Model

Now I shall propose a formula that enables us to observe the working of grants economy, firstly in general and secondly as adapted to rural America. Symbolically, the forces that come to bear on the income level of an economic unit (such as household, region, country) may be examined by means of the following simplified model:[2]

$$y = \frac{L_h P_h + L_m P_m T + G}{L_h + L_m + L_u} \qquad (1)$$

wherein

- y = income per capita;
- L_h = the amount of labor or human activity devoted to production for home use;
- P_h = productivity of labor employed in activities for home use;
- $L_h P_h$ = total output for home use;
- L_m = labor employed in production for exchange through market;
- P_m = productivity of labor employed in activities for market exchange;
- $L_m P_m$ = total output for market;
- T = terms of trade, i.e., the ratio of exchange between exports and imports;
- $L_m P_m T$ = the total amount of goods and services obtained through the exchange;
- G = grants, i.e., unilateral transfers received and given;
- L_u = unemployed labor, which includes every person outside the production process and thus makes no direct contribution in work (young, old, sick, drones);
- $L_h + L_m + L_u$ = total population, i.e., all members within the economic unit.

Giving special focus to the grant element, it can be described in detail thusly:

$$G = f(G_e + G_i + GT + GP_h + GP_m + GX) \qquad (2)$$

wherein

- G = grant equivalent, i.e., total dollar value of unilateral transfer;
- G_e = explicit grants (subsidy payments, unemployment benefits);
- G_i = implicit grants (favorable tax treatment, etc.);

[1] The need for this kind of an approach has often been recognized as, for example, James Bonnen noted in his celebrated study on the distribution of benefits from cotton price supports [1, 224]: "The terms subsidy or subsidy program can be given only the most general meaning: the transfer of goods, services, or money by government to special groups in the society (composed of private firms or households) for which no equivalent service or good is directly rendered in return. Any government program that undertakes to provide services, or to create or preserve something of value for a group within the society, for which the group does not repay the total cost to government of providing this benefit, might be said to be subsidized. By this definition most government programs involve some element of subsidy. However, we are unable to make much analytical use of the concept subsidy."

Bonnen's melancholic reservation was further reinforced by his commentator Wiliam Capron, who emphasized, "If we are to have an effective public dialogue on the use of subsidies to accomplish public purposes, we must either find a term other than 'subsidy,' or we must eliminate the pejorative connotation of that term. For politicians, economists, and the public . . . the term 'subsidy' has come to imply something bad" [1, p. 251].

[2] Adapted from Kenneth E. Boulding, who introduced it at the National Conference on Social Welfare in 1961 [6, p. 47].

GT = positive and negative grant elements embodied in the terms of trade (parity);

GP_h, GP_m = grant to support productivity through education, capital improvement, research, mobility, etc.;

GX = additional grants, if any, emanating from other sources,

The complement to the grant equivalent is the exchange equivalent, E, the total of $E+G$ forming aggregate income Y. The grant equivalent can therefore also be expressed as

$$G = Y - E \tag{3}$$

In turn, upon dividing the grant equivalent by income we arrive at the grant ratio:

$$g = G/Y, \tag{4}$$

a figure which facilitates intersectoral and intertemporal comparisons.

When applied to agriculture, these formulae show that there are many alternative ways to alter the aggregate or per capita income of a farm or the whole rural sector. We can generalize, for example, by saying that per capita income tends to be increased, ceteris paribus, (1) by increasing P_h and P_m, i.e., the productivity of human activity, through better skill, more capital, and external economies; (2) by improving T, i.e., the terms of trade under which commodities are exchanged; (3) by increasing G, net grants, which results from higher grants received and lower tributes (negative grants) given away; (4) by reducing L_u, i.e., the unproductive and underemployed segment of the population.

One of the advantages of the above approach is that just a few variables are able to reflect the farm sector as a composite of exchange economy and grants economy. Because of the simplified ordering of variables some precision is apparently sacrificed; nevertheless the tractability of the model provides notable compensations, particularly when employed in the appraisal of policy alternatives. Indeed, the rest of this paper will attempt to demonstrate how grants economy sheds new light on old problems.

Grant Elements in Agriculture

Price support: grant to alter terms of trade

Among the highly visible roles of grants economy one is directed toward farmers as an occupational group. "Parity prices" are corrections for unfavorable terms of trade. Price support policy represents the society's response to a successful appeal by an agriculture that believes itself to be at a disadvantage in the exchange economy.

There is no need here to docket the controversies around parity prices in order to demonstrate the contribution of an analytical method which can ferret out exchange and grant elements. For example, the precise relationship between parity price ratio and parity income could be of special use when applied to intersectoral and intertemporal comparisons. Analysis along such lines might reveal, furthermore, that terms of trade adjustments are not at all confined to agriculture. Rather, such means distort the functioning of market forces in other industries too, although in these cases the disparaging label of parity pricing is not spelled out. Of course the discovery of a second wrongdoing should not slow down the eradication of the first mistake; yet farm sympathizers might more willingly accept the judgment of free market if they know that similar behavior will be expected from everyone.

Land diversion: explicit grant for compliance

Parallel with price supports, the other main channel of governmental grants to agriculture is payment for the idling of cropland. In a broad sense someone might even argue that these payments do "buy" something for the government; they prevent a buildup of excess stock of commodities which would require added storage costs. Thus production controls tend to alleviate the problems caused by price support; in fact a second grant attempts to reduce the distress of misallocation caused by a first grant.

By measuring the social costs of compliance with a long-drawn-out short-term program, grants economics can bring these payments into sharper perspective and can identify the incidence of the varying features of subsidies. The method lends analytical basis to a parable borrowed from rural setting which suggests that the present land diversion is analogous to bailing water from a boat in preference to fixing the leak.

Concretely, the payment of subsidy for idling acreage is bound to disturb the society increasingly as the current inflation amid unemployment prolongs itself. It is not inconceivable in the future that the prevalent monetary-fiscal blueprints will have to share in the policymaker's attention with other experiments. As the "demand-pull," "cost-push," and "demand-shift" theorems of inflation prove inadequate to diag-

nose a grave situation, new theorems and policies are prone to emerge with emphasis on "supply-pull." This problem is sketched in the appendix.

Surplus disposal: the incidence of PL 480 grants

Foreign aid had opened the way for disposal of agricultural surpluses. The mounting commodity stocks during 1953 and 1954 on the domestic side, along with the stark need for food and fiber in less developed countries, prompted the enactment of Public Law 480 (Food for Peace). What followed was the most extensive shipment of agricultural products the world has ever seen; over $20 billion of aid has been transferred under this program thus far. Due to the pronounced concessionary features of contract terms, these shipments entail a higher grant ratio (about 70–80 percent) than most other aid activities.[3]

Over the years there has been some political contention regarding the budget accounts to which the costs of PL 480 should be charged. On one side they are viewed as foreign aid expenditures. For example, the U.S. Congress in the Food-for-Peace Act of 1966 requires that the President, in presenting his budget, shall classify provisions under this act "as expenditures of international affairs and finance rather than for agriculture and agricultural resources" (Sec. 403). Undoubtedly foreigners benefit from the act. On the other side, however, it is equally true that shipment of commodities under PL 480 does affect the income of American farmers who receive the subsidized domestic price for the volume removed from home markets. In fact the above practice overstates the international affairs budget by that portion of the monies which the Commodity Credit Corporation would have spent anyhow.[4]

The new analytical insight of grants economy promises the clarification of several issues. The delineation of exchange components versus grant components within a transaction offers the point of departure. The natural next step is to determine the incidence of grant elements, that is, the precise gain paid to each beneficiary, some of whom might not even have been known before. An example in case is the computation of the grant equivalents that accrue to foreign grantees, American farmers, and American shipping lines as a result of a particular PL 480 delivery. The policy implications become evident when we recall the current practice of national account statisticians who enter the full amount into the balance of international payments even though a certain proportion of the grant does not go abroad but is transferred to American farmers and shipping firms. According to some proposals these latter items should rather figure as transfer payment entries within the national income accounts.

Tax structure: the perplexity of implicit grants

"The power to tax . . . is not only the power to destroy but also the power to keep alive," reads a pronouncement of the United States Supreme Court. Forgiving someone's obligation to pay a tax dollar, like a borrowed dollar, is similar to presenting him with a one-dollar gift. Preferential tax treatment has long been recognized as a potential source of personal income. In grants economics this is one branch of a broad assort-

[3] Illuminating discussions of the subject are offered by Tweeten [35, pp. 460–498] and Pinstrup-Andersen [27]. For economic analysis and policy evaluation see recent studies by Horvath and associates, as outlined later.

The model designed for foreign aid analysis reads as follows:

$$(5)\quad g = \left[1 - \frac{i}{q}\right]\left[1 - \frac{e^{-qM} - e^{-qT}}{q(T-M)} + g_1 + g_2 + g_3 + g_4\right]$$

wherein

- g = grant ratio, i.e., the unilateral transfer portion of resource flows;
- i = interest rate charged;
- q = comparative rate of discount, i.e., the opportunity cost;
- T = time of maturity in years;
- M = moratorium on repayment, i.e., the grace period;
- g_1 = grant erosion due to aid tying;
- g_2 = grant element due to soft currency repayment provisions;
- g_3 = grant ratio adjustment related to surplus disposal programs;
- g_4 = grant ratio adjustment from terms of trade.

A study of the donor countries for the period 1953–69 shows substantial variation in grant ratios, from as high as 0.90 for Australia to as low as 0.12 for Switzerland. The total U.S. aid commitment figure was $65.9 billion; the total grant equivalent amounted to $47.9 billion; and the corresponding weighted average grant ratio was 0.7269 [19]. Another point of interest is the ranking of countries in order of grant equivalent: 1. U.S., 2. France, 3. U.K., 4. Germany, 5. U.S.S.R., 6. Australia, 7. Japan, 8. Canada, 9. Belgium, and so on [14].

[4] Jointly with Donald P. Minassian I have recently prepared an econometric treatment of grant erosion that results from aid-tying [18]. The list of other closely related studies includes a delineation of basic concepts [14], a mathematical formulation of true grants [17], a recount of the grant component in U.S. economic aid programs [19], and the grants economy in international perspective [8].

ment of implicit grants; indeed, the magnitudes involved are much greater than the uninitiated observer could have imagined. Although the phenomenon is not confined to agriculture alone (as a glance at depreciation allowances or import restrictions should exemplify), here we shed some light on the working of implicit grants in the context of the American farm economy.

Pertinent studies have repeatedly noted that the farm sector reports to the Internal Revenue Service a taxable income far below the performance recorded by the U.S. Department of Agriculture; for example, in 1964 individuals reported \$2.6 billion while the Agriculture Department estimated \$13 billion. The approximately \$10 billion "farm income gap" stems from various sources. To borrow Houthakker's calculations [22, pp. 12–13], the imputed value of food produced and consumed on farms was about \$1 billion and the rental value of farm dwellings about \$2 billion. But the major discrepancy, about \$5 billion, can be traced to a peculiar treatment of "expenses."

Traditionally, working farmers and ranchers have been permitted to deduct from income all expenses of their operations, including the cost of raising their crops and herds. When they sold part of the inventory they were allowed to treat the profit as capital gain, taxed at the maximum rate of 25 percent. However, the chief beneficiaries have proved to be wealthy investors, prosperous professionals, and high-income business executives who have utilized farm privileges for large-scale tax avoidance. This ironic situation reveals again how evasive implicit grants can be; misapplied grants accrue through the channels of agriculture to individuals outside of this segment of the economy.

Productivity improvement: how extravagant is granting?

Motivated by the enhancement of productivity, governmentally supported knowledge dissemination has played a prominent role in American agriculture. During the past hundred years a total of 99 million acres were endowed to land-grant colleges. Further endowments went for research in agricultural sciences, for extending knowledge to farmers, for teaching vocational agriculture in high schools, and so on. Many farms benefited from the Bureau of Reclamation, which makes water available to agricultural users at a price significantly below economic costs. Nevertheless, no qualms of conscience will upset the advocate of agricultural interests when he compares these subsidies with public grants to others. Just the mention of tariff protection to textiles, depreciation allowances to oil wells, or reduction of labor supply by craft unions will suffice. During the last two decades a prominent example has been the heavy subsidy involved in the government's program for developing civilian nuclear power or the telestar communication system. Indeed, communication and transportation have persistently been the recipient of sizable explicit as well as implicit grants. As a first major venture in the early 1800's the Erie Canal was completed with heavy financial support from New York State. Federal and state government aid was conspicuous in the railroad industry from the beginning: close to 180 million acres were allotted (131 million federal and 41 million acres state awards) [34, p. 115]. Subsequently shipbuilding and nowadays aviation have become the favored ones. With respect to the business sector at large, Robert J. Gordon in a recent article writes about "a little-known \$45 billion treasure chest of plant and equipment which the U.S. Government has purchased for the use of private firms" [13, p. 221].

In a general sense the output of resources allocated to productivity improvement benefits the whole society in the form of better quality and lower prices, although returns are so diffused through space and time that often connection between the exchangeables created and past outlays becomes dissipated. A much more clearly identifiable beneficiary is the producer whose production function improves. When taking this vantage point it turns out that among the recipients of federal R & D (research and development) funds the relative position of agriculture has declined from 2.5 percent in 1957 to 1.6 percent in 1968. Specifically, during these 13 years the increase of total R & D outlays from \$3.9 billion to \$16.2 billion was accompanied by a significantly slower increase for agriculture, from \$100 million to \$258 million [20].

Concessionary loans: the grant elements in long-term finance

Credit allocation has long been regarded as a policy instrument, whether designed to stimulate improvements on farms or to encourage structural changes. An effective technique at the disposal of the policy-maker is variation in the concessionary terms of a loan, such as interest charges below market rates, longer repayment time, moratorium on interest, or installment payments, etc. Whichever alternatives are chosen, we

can generalize that the grant equivalent of a dollar loan will be larger, ceteris paribus, the lower the rate of interest, the longer the repayment time, and the more moratorium is allowed. The formula introduced above for the computation of international grants can be easily adapted to show the grant elements in farm loans.

The calculation of grant elements should cause no problem when a somewhat different approach to agricultural support credit is used, namely, guaranteed funds. The assumption of risk is amenable to economic analysis. Since in this case the government guarantees the repayment of ordinary bank loans if defaulted by the borrower, it is advocated by those who want to minimize interference with market forces. Even though the market rate of interest prevails, the government can still ensure that selectivity will be observed through the criteria prescribed for the Farm Credit System, the Farmers' Home Administration, or other agency.

Income distribution: a case of misapplied grants

In rural America the grants economy works counter to the professed goal of its creator, the law. The evidence is growing to overwhelming proportions; for example, Theodore Schultz writes,

> As presently practiced in the United States, farm price supports predominantly benefit farm families who are well above the poverty line; high price supports impede efficient resource allocation and also confound the income-wealth paradox in agriculture. . . . The value of wealth, which consists mainly of farmland, is subsidized; the value of farm work is depressed by acreage allotments and other measures to contract production. Thus these programs are strongly biased in favor of farm wealth (income from property) and against income from farm work [32, p. 182].

We can generalize by saying that since programs are vested not in the farmer but in his land and equipment, grants mainly depend on farm size and production. The exact figure for grant flows is subject to debate, but even the most conservative studies estimate that 40 to 50 percent of realized farm income is generated by the government programs [1, pp. 225–226]. The total annual subsidy, according to Charles Schultze [33, p. 1] is between $9 billion and $10 billion, including annual direct outlays from the federal budget of some $5 billion and about $4.5 billion in higher prices of agricultural products paid by consumers as a result of administered prices.

To remedy the situation there are several program proposals that place priority on aiding low-income families. An important observation relevant to policy overhaul comes from E. J. R. Booth, who observes that poverty is no longer connected with agriculture in rural regions because the intermediate and lower end of farm income groups have switched their dependence from farm to nonfarm income to a significant degree [2, 428–29]. Such findings further accentuate disappointments with farm subsidies. The emerging consensus seems to favor direct income payment to poor families, managed as a complement to the tax system.

At this point our involvement with efforts to rectify a labyrinth of misapplied grants could be enlivened by a small glossary to the current history of economic thought. How the world registers the paternity of a specific idea might be of no consequence to such productive minds as Kenneth Boulding and Milton Friedman; nevertheless the student of current history will be amused when he searches for the roots of income-maintenance policies. In order to gain acceptence in a society that cherishes an individualistic philosophy, the idea of institutionalized care for the poor probably needs the label of Friedman, who is regarded as the laissez-faire protagonist, rather than that of Boulding, whose image is of the humanitarian social scientist. Indeed, on the alleviation of poverty Friedman's sketch in his *Capitalism and Freedom* [12, p. 192], published in 1962, is the standard reference today. On this specific topic, few (if anyone) quote from Boulding's "Reflection on Poverty," published in 1961, which reads:

> Even as a society gets richer, there is still a residuum of poverty. . . . It is not unreasonable to suppose, however, that as a society gets richer the minimum level of income which it is prepared to support rises. . . . We could suppose, for instance, that we had an income tax which became negative below a certain level of income; that is, above a certain level one would pay taxes, while below a certain level one would receive subsidies. By making the marginal subsidy at some point 100 percent, it would be possible mechanically to prevent anybody's income from falling below a certain level [6, pp. 55–56].

However rewarding it could be to touch upon the various implications of income redistribution in agriculture, I shall confine myself here to mentioning one dilemma. History teaches that certain societies' attempts to make income in-

equality less pronounced have occasionally led to deplorable dynamic consequences. The elasticity of supply of unproductive individuals may be large and thus an undertaking to support them may produce such consequences. (This is variable L_n in my initial formula, i.e., the ones who do not leave the farm for other occupations.) The answer quite likely lies in an income-supplement plan that entails incentive features, such as, for example, outlined by Booth [2, p. 436–437].

Revenue sharing: new redistributive grants

Not even an introductory sketch to grants economy may omit comment on revenue-sharing by the federal government with state and local government. The Administration's plan would allocate for this purpose about $5 billion in 1973, which amount to 1.3 percent of taxable personal income and 3.8 percent of total state expenditures. Although the proposals envision relatively small amounts, the new legislation, if enacted, may open new broadening avenues. Whatever implication revenue sharing might have on matters of fiscal organization, the redistributive effects appear quite obvious. While all state and local governments would receive funds under revenue sharing, the federal treasury would return proportionally more to the poor states than to the rich ones. A further redistributive effect becomes evident upon considering that state and local taxes are less progressive than the federal income tax. If one dollar coming from revenue sharing were substituted for state taxes that would otherwise be collected to finance local expenditures, the effect would generally be favorable to lower-income groups.

How would rural America fare under such innovations and how would they affect the thorny problem of tax incidence? The analyst finds several promising lines of investigation. I mention a few. Is it likely that the rural poor would finally receive less unequal treatment in comparison with his urban counterpart? Where would the well-to-do farmer's interest lie; would it depend on his wealth? If his contribution to a local project were channeled through federal income tax collections, he would be hit harder the larger his farm and income. On the other hand, if the same project were exclusively financed through local tax collections, his property tax must increase substantially.

Beyond the general revenue-sharing aspect, the pending legislation entails special revenue-sharing proposals to reconstruct current arrangements. The more than 500 existing aid programs would be consolidated into six major branches, one of them concentrating on rural community development grants. Advocates of the reform argue that the present system is overcentralized on one hand and unduly fragmented on the other: grants for similar purposes are often handled by several different agencies; most grant programs have voluminous requirements and the forms designed to ensure compliance are complicated documents that require experts to decipher. "A number of cities and states have gone so far as to set up special offices devoted solely to finding out what grants are available. . . . Others have turned to private consulting firms that specialize in selecting grants from the cluttered federal menu. Despite these efforts, an element of inequality remains for those less adept at grantsmanship" [34, 159], which almost amounts to saying that only the rich can afford to ask for grants.

Interdependence of Utility Functions

By definition, in the process of granting the donor's net worth is diminished; but this does not imply that he receives no psychological benefit or social reward for the act of making a transfer. Having noted at an earlier point that the grants economy performs as a "regulator" of systemic interactions in the macroeconomic dimensions, we can now observe some microeconomic implications. Grants economics provides a microtheory of transfers by perceiving the interdependence of utility functions among individuals. This supposition runs parallel to the assumption of interdependence of production allocations, where goals other than profit maximization are recognized, such as output maximization, infrastructure development, environment control, creation of goodwill, etc. Such conceptualization of the interdependence of utility functions leads to a broader concept of social welfare, which includes (1) the utility derived from the contemplation of another person's welfare and (2) the utility derived from giving because it conforms to the individual's norms.

These as well as other cornerstones of grants economics come from Kenneth Boulding's scrutinizing reappraisal of contemporary economic tenets. Referring to some of them he writes,

> Anything less descriptive of the human condition could hardly be imagined. The plain fact is that our lives are dominated by the very interdependence of utility functions which the Paretian optimum denies. . . . Economists' almost complete neglect of the concept of malevolence

and benevolence cannot be explained by their inability to handle these concepts with their usual tools. There are no mathematical or conceptual difficulties involved in interrelating utility functions, provided that we note that it is the perceptions that matter. The familiar tools of our trade, the indifference map, the Edgeworth box, and so on, can easily be expanded to include benevolence or malevolence, and indeed without this expansion, many phenomena, such as one-way transfers, cannot be explained [3, 126–27].

It takes little effort for economists to envision mentally the Edgeworth-Bowley box diagram modified so that the contract curve does not go all the way from the southwest corner to the northeast corner but becomes shortened on both ends. This is the result of benevolent behavior: the individual's increased utility due to more consumption is outweighed by his decreased utility due to the perception of the other's miserable state. In contrast with the Pareto optimum, the tractability of the Boulding optimum is bound to have particular appeal. In studies of strategy it may appear as a positive-sum-game; in general theory it sheds light on returns to scale and on external economies; in a broader context it amounts to saying that whether life on earth is hell or heaven depends on the attitude of one human being toward others. A nomenclature of all the concepts, as well as their mathematical exposition, has been offered by the quickly expanding list of publications of Martin Pfaff and Anita B. Pfaff [28, 29, 30, 7, 9].

Surely anybody could find it a vain attempt to list the innumerable occasions in rural life where the interdependence of utility functions has been a very basic organizer of life. Yet heretofore it was usually lumped under the miscellanies of ceteris paribus and thereby its potency went only casually observed and wastefully underutilized in policy analysis. Now the grants economy opens new vistas for rigorous inquiry.

Appendix

Institutional Inflation Via Misapplied Grants

The most perplexing problem of present-day American economy, namely, the coexistence of inflation and unemployment, may also receive new light from grants economics. According to the prevalent neoclassical school of economics, unemployment should cause price deflation. Neatly depicted by the Phillips curve, the idea has brought perspective to the historical course of economic fluctuations and promised a workable policy tool. But what a dismal science economics truly is may just begin to dawn upon us as policy-makers find themselves no longer free to choose between two evils, or to settle half-and-half; rather it appears that we must endure both in full vigor. Taking off from this gloomy premise, I have been advancing the following propositions:

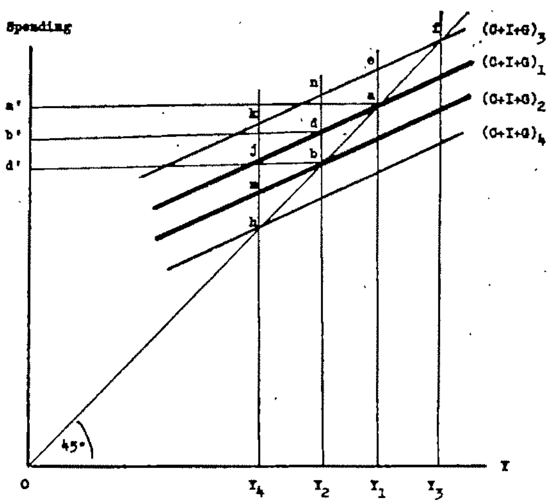

Figure 1. Inflation during recession

Firstly, that the institutional framework of contemporary economy prompts paradoxical situations wherein implicit grants accrue to privileged groups in compensation for the restraint of market supply;

Secondly, that since the modern national economy is subject to a high leverage from explicit and implicit grants, a rearrangement of these transfers so as to weaken capacity-curbing and simultaneously to strengthen supply-pulling influences can lead to less painful recovery than other alternatives in sight.[5]

Figure 1 illuminates some basic relationships. Following is a list of its symbols:

Y_1 = potential full capacity;

$(C+I+G)_1$ = aggregate demand that is consistent with full employment and price stability;

Y_2 = restrained capacity utilization;

$(C+I+G)_2$ = depressed aggregate demand which could exert downward pressure on prices;

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[5] I elaborate on these matters in a paper [15] scheduled for the annual convention of the American Economic Association in New Orleans, December, 1971. Preliminary drafts are available.

$b-d$ = "dislocation gap" ("quasi inflationary gap") due to capacity underutilization;

$(C+I+G)_3$ = excessive aggregate demand;

$a-e$ = inflationary gap with full employment;

Y_4 = capacity under utilization in response to anti-inflationary policies;

$(C+I+G)_4$ = deeply depressed aggregate demand which could give recessionary price stability

$h-j$ = dislocation gap during recession;

Y_3 = expanded capacity resulting from well-applied grants policy.

If aggregate demand is $(C+I+G)_1$ while the full production capacity is at Y_1, the level of national economic activities will be OY_1 and stable prices will prevail. But if factor operators restrain capacity, the actual performance will stay below potential. The subpotential level may be at Y_2. Consequently, aggregate supply tends to fall short of aggregate demand and there appears to be what I shall label a "quasi-inflationary gap," $b-d$.

The label, quasi-inflationary gap, may initially strike the reader as a misnomer. However, this designation is quite consistent with the overall structure of macroeconomic analysis. It is true that under the post-Keynesian conventional nomenclature only a deflationary gap could exist during recession, and no inflationary gap. Nevertheless, I propose to perceive the adjectives inflationary and deflationary as functional and dynamic definitions rather than as taxonomical and static terms. Conceptually what really matters is that people are *trying to buy more than is actually being produced* and they are thereby inflating the price level. Whether the underlying reasons are elemental calamity, lack of adequate capacity, or simply restraint of production, the heart of the problem is that supply lags behind demand. Specifically, in our diagram the amount of spending $O-a'$ need not cause inflation if full capacity Y_1 is allowed to produce; but with curbed capacity Y_2 even the lower spending level $0-d'$ becomes inflationary and spending as low only as $0-b'$ could promise stable prices. Since the situation results *not* from the absence of factor endowments and employable capacity but institutional straightjackets and dislocations, the label quasi inflationary gap seems appropriate. As an equally descriptive synonym, the term "dislocation gap" may be preferred on occasion.

Someone might oppose my approach by arguing that instead of Y_1 I should regard Y_2 as the level of full employment capacity which in turn would tend to bring about a lower aggregate demand, $(C+I+G)_2$. In this vein point b would eventually prevail as full employment equilibrium with stable prices. However, the objection is unrealistic because de facto there exist factors of production (labor, land, capital tied up in plants) which even when idle still claim rewards. For example, just because some equipment is left outside the production function the corporation does not cease to pay interest on the bonds that financed that particular investment outlay. A variety of fixed costs must be met for the full capacity Y_1 and not just the restricted level Y_2. In a broad sense several other items belong to this category, such as payments to unemployed labor, featherbedding, some agricultural subsidies, and so on.

The leitmotif of my argument reflects the suspicion that it is the institutionalized drain on the energies of the national economy that throttles full capacity production. The institutions of society have become increasingly geared to the idea of "protecting" privileges that entitle organized groups to secure their particular slice in the national pie, once attained. Fading are the voices advocating that the rules of the game, not achieved privileges, are worthy of protection. Under provisions of law or sanctioned by conventions, grant is given for non-achievement; extraproportional income, wealth, and power are thus accorded to some strategically located groups in spite of the disservice rendered. The paradox of misguided grants reveals itself most painfully in the inherent dynamics of a situation in which those scattered individuals who would refuse the collection of tributes are penalized as long as others ignore their scruples.

Since misapplied grants are at the roots of the prevalent inflation-ridden unemployment, the next order of business is to distinguish grants that are counterproductive from those that are conducive to optimal capacity utilization. In the context of my model, the main trust is the expansion of supply. Under a rearranged system of national priorities, grants would flow to those operators who excel in capacity utilization instead of practicing restraint.

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Political and Social Implications for Rural Areas of a Nationalized System of Welfare

James M. Lyday

Nearly two hundred years ago our country proclaimed an independence from colonial rule. The rhetoric of that proclamation is well known and moves us all to wonderment and awe. Those who wrote these lines were not, however, so awed. They were politicians as well as philosophers; and reality, which gave freedom to to their declarations, constrained their actions.

The libertarian rhetoric proclaimed by Jefferson's Declaration of Independence was followed by a Constitution cast from a much more conservative mold—so conservative it must be remembered that it was politically unacceptable until the first ten amendments were added.

The impact that later and more radical administrations had on the social, political, and economic future of the nation was not in their own time foreseen or understood. Jefferson, the apostle of limited powers and decentralization not only doubled the nation through the Louisiana purchase in a constitutionally unauthorized and extralegal fashion but also gathered the authority of the federal government in a fashion that was to lay the foundation for a denial of states rights doctrine half a century later. Lincoln organized the nation to fight the civil war and at the same time broke Jacksonian populism with the industrial and financial powers let loose in that war which held the nation in sway for the next half century.

An understanding of the importance of these two realities of schoolboy history is important because it reminds us that rhetoric is not in itself change and that change, when it comes, frequently passes unnoticed, being more modest in scope than its rhetorical justification and established in language that bores rather than excites.

Two examples from our own century are illustrative. The 16th amendment, which permitted the imposition of a federal income tax, was viewed with equanimity by William Howard Taft who proposed such an amendment. Although Joseph Choate had successfully argued the unconstitutionality and "communist" origins of such a law in 1895 before the United States Supreme Court, the passage of this constitutional amendment was not, in spite of such fears, generally foreseen or feared as the major instrument of taxation and economic policy it has become.

The Social Security Act of 1935 provides a further and more contemporary example of law which when established did not appear to be an engine of massive economic and social change. It is comprehensible that legislators of that period were without such insight, but professors of political economy had no such excuse. Edwin Witte of the University of Wisconsin, who in effect wrote the bill, was one of the very few who saw its potential and in 13 months drafted the bill and shepherded it through enactment.

The analogy which—perhaps tediously—has been prepared is that H.R.1 will, if enacted, nationalize the basic system of income maintenance in the United States and will have a long-term effect on the social and economic life of America comparable to the 16th amendment or the basic Social Security legislation of 1935. It will not, contrary to the expectations of some, have any significant immediate economic impact anywhere in the United States. This should not lead to the error of assuming that its long-term effects will be minimal. A consideration of the basis of each of these conclusions follows.

Immediate Economic Effects

The following summary of the provisions of H.R.1 is divided into two parts: (1) changes provided by the bill in the traditional field of social insurance—retirement provisions and health protection; (2) changes made in welfare programs under that legislation. In both cases this summary will note the program change, the numbers of beneficiaries, and its cost.

Retirement and medical insurance

Although the Old Age, Survivor, Disability, and Medicare provisions of the bill will, according to the committee report [2], increase federal costs by $5.4 billion during the first year following enactment, a simple examination of those increases demonstrates the modesty of their effect. Social Security payments will rise by 5 percent; at the basic benefit level that means that payments will increase from $70.40 to $74.00 per month. The average benefit will rise from $133 to $141 per month. These increases do not make the pulse go faster. This increase when divided

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among the 27.4 million beneficiaries will cost $2.1 billion.

The retirement test under Social Security will be relaxed to permit $2000 of earnings prior to a reduction in benefits. Benefits will be reduced by 50 percent for additional increases in earnings. This will increase the spendable income of 500 thousand beneficiaries and will cost $700 million.

3.4 million widows will receive 100 percent of the benefit that their husbands would have received. This will cost $760 million.

1.5 million disabled Social Security and Railroad Retirement beneficiaries will become eligible for hospital and physician coverage under Medicare. Cost will be $1.85 billion.

Many persons would object to an inclusion of the Social Security increases within our consideration because the mythology insists that such benefits are somehow "earned." Even when we reject that injunction, the distribution of funds to such a large number of widely scattered beneficiaries, who are by no means all poor or even near poor, will in effect guarantee that visible effects of such increases will be practically nonexistent.

Welfare program changes

That part of the bill which is more generally viewed as welfare will federalize the existing Old Age Assistance, Aid to the Blind, and Aid to the Permanently and Totally Disabled into one program paid in large measure by the federal government and will also replace the existing Aid to Families with Dependent Children system by a national system run jointly by HEW and the Department of Labor. The total cost of these two welfare program reforms is estimated by the committee report to cost $14.0 billion in fiscal 1973 [2, pp. 212–213]. This is by no means all or mostly all new money. Indeed the marginal cost of these two programs is less than the new costs of the increase in the Retirement, Disability, and Medicare provisions of the bill. New costs of the Adult and Family programs are estimated at $3.2 billion in excess of existing costs. Only $1.2 billion of this amount will accrue to families, while $2.0 will be received by the adult categories, mostly the aged. Indeed the most singular effect of the bill will be to very nearly eliminate poverty among the aged as defined by existing poverty guidelines.

The most heralded program to provide income for the working poor will thus receive only $1.2 billion, and these funds will be distributed among

Table 1. Comparison of existing and proposed federal-state income assistance payment programs, by category of assistance, 1973 (million dollars)

Category	U.S. total	Twelve southern states	Seven industrial states	All other states
H.R.1 adult	5,656.2	1,462.0	2,615.1	1,579.1
Existing adult	3,614.2	863.1	1,736.6	1,014.5
Added cost of H.R.1	2,042.0	598.9	878.5	564.6
Percent of total new costs	100.0	29.3	43.0	27.7
H.R.1 family	8,316.8	1,297.8	4,821.2	2,197.8
Existing family	7,155.3	909.6	4,442.5	1,803.2
Added cost of H.R.1	1,161.5	388.2	378.7	394.6
Percent of total combined costs	100.0	33.4	32.6	34.0
H.R.1 (combined)	13,973.0	2,759.8	7,436.3	3,776.9
Existing (combined)	10,769.5	1,772.7	6,179.1	2,817.7
Added Cost of H.R.1	3,203.5	987.1	1,257.2	959.2
Percent of total new costs	100.0	30.8	39.2	30.0

Source: *Social Security Amendments of 1971: Report of the Committee on Ways and Means on H. R. 1* [2].

7.7 million program eligibles. Existing income assistance for families in the southern states is on the average the lowest in the union. Southern states also have the highest percent of their population poor and thus have the highest proportion of their citizens eligible for assistance under the new bill.

Twelve southern states (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia) will receive an estimated $388 million of this $1.2 billion or one-third of the total.

Interestingly enough, seven high-income industrial states (California, Illinois, Massachusetts, Michigan, New Jersey, New York, and Pennsylvania) will also receive approximately one-third of all new family assistance monies. When family assistance funds are combined with increases in the adult welfare categories, these seven states receive nearly 40 percent of the total [2, pp. 214–215]. These data are summarized in Table 1.

Southern states will nonetheless receive more than a proportional share of the funds provided under the welfare provisions of H.R.1. Mississippi has long been the favorite example of the southern state where poverty is most severe and where public assistance least provides for an adequate income. Therefore if H.R.1 is going to effect a major and immediate economic change, Mississippi is surely the place to look.

The committee report estimates that Mississippi will receive an increase in payments in the adult categories of $73.5 million and in the family categories of $39.3 million [1, pp. 212–213].

The number of eligible persons in adult and family categories nearly triples. Family beneficiaries will increase from 157 thousand to 451 thousand, and adult category eligibles will rise from 63 to 174 thousand [2, pp. 227–228]. Unfortunately, when distributed among so many persons these new millions will not (except among the aged) purchase a much higher standard of living. The average payment to new beneficiaries among the aged is $1167 a year. The increase in income for new beneficiaries among those eligible for family assistance programs will be $134 per year.

It is difficult, however, to imagine the effects of such increases without some more specific reference. I have accordingly estimated the change that such a program might make in personal income in a theoretical Mississippi county.[1] It should be noted that the Ways and Means estimates of increases in coverage statewide are 2.9 percent under the adult programs (3–5.5 used in example) and 13.3 percent in the family programs (17.5–25.0 in example).

Given these assumptions, per capita income might increase by 1.7 to 4.3 percent before consideration of multiplier effects as a result of adult programs and 1.2 to 2.2 percent from family programs. The combined rise in county personal income would therefore range between 2.9 and 6.5 percent before allowing for multiplier effects.[2]

Some additional funds will accrue to the people of Mississippi along with the rest of the country from new federal expenditures in child care, work training, public service employment, and the service and administrative costs of the program. Approximately $1.8 billion in additional costs are associated with this segment of H.R.1. Its total effect on our hypothetical county might raise county personal income by an additional 1 percent.

The maximum direct increase in county personal income of the bill therefore ranges from 3.9 to 7.5 percent. It is probable that the total financial effect of this program, including multiplier effects will therefore raise county income by less than 10 percent.

An accurate if colloquial description of the bill's likely immediate financial effect in the poorest counties in the nation's poorest state would therefore be that poor people will have more to eat and somewhat better clothes—especially the aged.

Political and Social Effects

Those of us who live on incomes that are many times the official poverty lines are apt to view these changes in somewhat the same social and political perspective as Marie Antoinette, even if we are cleverer than she was with respect to public announcements. We tend to forget that for a family of five an increase of $670 a year may represent one-fourth to one-third increase in spendable income. Seen in this light the effects of the program take on a different aspect.

Moreover, political leaders will discover a new aspect of the manifest reality of such an occupation. Welfare payments that are limited to a relatively small and predominately black population can be dammed with impunity, but one that enrolls a sufficient number of whites to reverse that racial composition and carries 20 millions on its rolls will be damned only by those seeking political retirement. In my home state of Oklahoma the term "nigger" was a phrase I am told that paled beside the epithet "squaw man" until the Indians received land titles. Today it is not essential but any politician is pleased to note or invent the fact that some of his ancestors were Indians.

When the increase in income is structured in a manner that virtually eliminates the authority of the local (i.e. feudal) power structure to affect

[1] The assumptions in this undertaking are as follows:
Per capita income in fiscal 1973:
1. $1,500
2. $2,000
Percent of population receiving welfare:
1. Adult programs
   a. Existing law
      (1) 5.0
      (2) 7.5
   b. H.R.1
      (1) 8.0
      (2) 12.0
2. Family programs
   a. Existing law
      (1) 7.5
      (2) 10.0
   b. H.R.1
      (1) 25.0
      (2) 35.0
Population:
1. 15,000
2. 30,000

[2] An interesting facet of the data estimation published in the committee report of H.R.1 is that in 9 of these 12 southern states payments to newly eligible families exceed the total increased program cost. This would imply benefit reductions for existing beneficiaries. Such a result could be partially accounted for by the fact that southern states have traditionally permitted beneficiaries to earn an amount which when added to benefit payments would equal the state need standard. It is difficult to imagine that this circumstance could totally account for the reduction in Mississippi where the payment per person among program beneficiaries is about $12 per month.

that increase, the effects of the program are apt to be radically different from those simple income measures would indicate. Many persons are concerned that the work registration requirement of H.R.1 will give local officials a whip hand over program beneficiaries. I am not so concerned. First, an unemployment rate in excess of 6 percent forces action in this direction to be modest; second, the requirement that wages must equal at least 75 percent of the current federal minimum wage (at present 75 percent is equal to $1.20 an hour) will, if enforced, compel substantial increases in critically important wage levels, particularly in the South.[3] Furthermore, every indication from Washington, and particularly from the Ways and Means Committee, is that the minimum wage will be increased to $2.00 an hour before next November.

The philosophical import of this change should not be lost on economists. The traditional argument that such increases in the minimum wage will result in reduced employment can now be countered with the observation that, even if that is true, protection afforded by H.R.1's income guarantee will protect the affected worker. Society can then make judgments about the desirability of permitting employment at levels beneath some annualized rate without confronting the specter of forcing those for whom we seek higher wage incomes being forced by unemployment to live on drastically reduced incomes.

I have argued that the enactment of the Family Assistance Program (the previous incarnation of H.R.1) would result in revolutionary changes in America.[4] I made this argument because among other considerations I believed that such legislation would compel a reexamination of the basic Social Security retirement program, Unemployment Insurance and Veterans Disability Insurance Programs, Food Stamp, Medical Care, and general agricultural support programs. H.R.1 has already restructured the Old Age Assistance program and has provided that the cash equivalent of food stamps be made a part of direct financial assistance.

The truly revolutionary character of H.R.1 is not in the fact that it forces reexamination of all income support programs, although that in itself is of formidable significance. The revolutionary aspects of this program are that it guarantees a basic income to all families, a guarantee I am confident the Senate will enlarge to one covering all Americans whether or not they have children, and that the guarantee will inevitably rise and rise rapidly. I would predict, for example, that the guarantee for a family of four will be in excess of $4,000 in less than a decade.

Finally and most importantly, the bill will cause wage rates to rise rapidly. The South in particular will shortly be required to pay wage rates comparable to the rest of the United States, and this will increase very significantly the economic growth rate of the South and its attractiveness as a place of residence.

The political and economic changes that will follow quickly in this path will, I believe, amaze all of us. The South has always been the heartland of populism. H.R.1 will facilitate the emergence of rational economic populism in that region, untainted by its traditional accompaniment of racism. The Democratic party, I think, will be the largest beneficiary of this new populism and will as a consequence rapidly lose its fear of the need to plan and control prices, production, and wages.

I have predicted that the immediate and direct financial effects of the passage of H.R.1 will be very small. I have also predicted that the longer-term economic, political, and social effects of that program will be revolutionary. Whether or not my argument is persuasive depends in large measure on the conception of the program as a national income guarantee that (1) cannot effectively be denied by local authority and (2) will rapidly increase in size and coverage.

H.R.1 will not provide very much money to anyone, but it provides the basic guarantee and opens the political gates for meaningful increments in its coverage and level. I am told, however, that money cannot provide respect, or happiness, or love—I refer of course to Confederate money.

[3] Nothing is so bitterly amusing as to read letters to the editor in small and large circulation newspapers (particularly in the South) about the difficulty of finding good domestic workers at a "fair" price. All too often a fair price works out to less than $1.00 per hour.

[4] See [1] for the argument.

References

[1] LYDAY, JAMES M., "Criteria for Income Maintenance Programs," in *Increasing Understanding of Public Problems and Policies, 1970*, Chicago, Farm Foundation, 1970, pp. 65–73.

[2] U.S. Congress, House, *Social Security Amendments of 1971: Report of the Committee on Ways and Means on H.R.1*, 92nd Cong., 1st sess., 1971, *House Rep. 92–231.*

Implications of a Negative Income Tax for Rural People

D. Lee Bawden

The effects of a negative income tax on rural people are largely unknown. A program based on the negative tax provides a maximum payment to families with zero or negative earnings and specifies a tax rate at which the payments are reduced as earnings move upward from zero. These two features will individually and in combination affect many aspects of household and business behavior. One can identify and hypothesize the likely directions of many of these effects, as I shall do later, but it is difficult if not impossible to predict the magnitudes of these changes from available secondary data.[1]

It is for this reason that we now have four separate negative income tax experiments, in various stages of operation, in the United States: one among urban families in New Jersey and Pennsylvania, to end this coming year; a rural experiment in North Carolina and Iowa, in operation for 19 months; and two other urban experiments, just beginning, in Gary and in Seattle and Denver.

I shall briefly discuss the setting in which negative income tax experiments began, the design and objectives of the rural experiment, some hypotheses about the likely effects of a negative income tax on rural people, the status of our analysis to date, some administrative problems we have encountered in the experiment, and some unresolved issues regarding the effects of Nixon's Family Assistance Program on farmers.

Genesis of the Negative Income Tax

Public assistance programs in the United States are generally regarded to be illogically conceived, poorly administered, and inequitably applied. Except for a sparsely funded AFDC-UP program (aid to families with children where th husband works less than 30 hours a week) in 2 states, a household headed by an able-bodie male under 65 years of age cannot qualify fo public assistance; yet two out of every five poo people in the United States are in such house holds.

Students of poverty have been convinced fo some time that something must be done to reforn our welfare programs. It has been almost 1 years since Milton Friedman proposed a negativ income tax as an alternative to existing program [6]. His proposal, and many similar ones tha followed,[2] called for providing assistance to peo ple merely because they are poor, rather than be cause they fall in some special category such a being disabled, husbandless, blind, or aged.

Nearly five years ago Heather Ross, a grad uate student at M.I.T., proposed to OEO tha they experiment with the negative income tax. A the time of this proposal neither academician nor politicians believed that such a radical pro gram would be politically acceptable befor 1980. However, Ross's proposal received a sym pathetic hearing from OEO researchers, and tw years later OEO funded a negative income ta experiment involving 1,250 urban families in Nev Jersey and Pennsylvania.

This was followed by a grant to the Povert Institute by the Ford Foundation to plan a simi lar experiment for the rural sector. The experi ment was subsequently funded by OEO and be gan operating in December 1969.

The Rural Experiment

This study involves 970 families in 810 house holds. About three-fourths of the total sample ar headed by males less than 58 years of age, wit the remainder evenly split between female head less than 58 and older heads of both sexes. Of th male-headed families under retirement age (65) 15 percent have farm income only; 43 percen are rural nonfarm wage earners; and the remain der, 42 percent, have both farm and wage in come. The sample was randomly selected fro two predesignated sites, North Carolina an Iowa, with 60 percent of the total sample i North Carolina. Fifty-five percent of the Nort

[1] Some attempts have been made from secondary data. See, for example, studies by Garfinkel, Greenberg, and Kosters, and Hall in [5]. But estimates vary greatly, and no one knows whether comparisons *among* households with different wage rates and different levels of exogenous income in the absence of a welfare program can be extrapolated to *changes* in (implicit) wage rates and exogenous transfer payments for individual families under a negative income tax.

[2] For a review of various proposals see [8].

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Carolina sample is black, and the Iowa sample is entirely white.

Only families below 1.5 the poverty line for their family size were eligible. These eligible families were then randomly assigned to either a control group (54 percent) in which they receive no payments, or to one of five different treatment groups (46 percent), in which they receive regular transfer payments. The treatments involve combinations of two experimental variables—the tax rate and the guarantee. Three tax rates are used—30, 50, and 70 percent; and three guarantees are combined with these tax rates—one-half the poverty line, three-fourths, and the full poverty line. Since the poverty line varies by family size, so does the guarantee. The negative tax rate is independent of family size and refers to the percentage decrease (or increase) in benefits as earned income rises (falls). In other words, a 70 percent tax rate means that for each dollar earned 70 cents of the benefit is taken away. This is analogous to a direct tax of 70 percent on earned income.

The experiment will run over three years, with the treatment groups receiving payments based on their levels of earned income as reported to us each month. The only restriction is that they remain within the United States. Both the control and treatment groups are interviewed quarterly over the three-year period to gather observations on the effects of the experiment.

The principal purpose of this study is to measure the effect of alternative tax rates and guarantees on work behavior—labor force participation, employment, hours worked, and occupation. Of secondary importance are a number of other objectives, including the effect of the program on migration, family health, school performance of children, expenditure patterns, borrowing, saving, family stability, organizational participation, and attitudes towards oneself and others.

Income reports are filed by the families each month and payments are made twice a month based on the reported income. The total cost of the program, including payments, research, and administration, will be slightly over $5 million.[3]

Hypotheses

There are a large number of hypotheses embodied in a study of this magnitude. I shall briefly describe some of the more important economic hypotheses. The first is that a negative income tax will reduce work effort of all employable family members. This is a direct consequence of both the income and substitution effects of the income-conditioned transfer payments [7]. A second, related hypothesis is that the most sizable impact of the program will be on secondary workers and on second jobs of primary workers.

It has been argued that farmers will exhibit less work disincentive than wage earners because of a stronger work ethic and a closer identification with their job. However, my third hypothesis is that work reduction of farm families will be *larger* than that of wage earners because of the second hypothesis above. Forty-six percent of all farm operators in the United States have an off-farm job sometime during the year and 8 percent more households have someone else in the family with a wage job.[4] These figures are probably higher among poor farmers, since nonfarm income makes up 78 percent of total net income for farms with gross sales under $10,000 [9].

A fourth hypothesis is that a guaranteed income will encourage farmers to shift to more risky enterprises. This shift will be subtle, however, because in the experiment, and in any likely national program, a family cannot get more than the guarantee by experiencing a negative income. Unlike for wage earners, the negative income tax does not provide a guaranteed annual income for the self-employed. In fact the total of net farm income plus the NIT payment could be negative, given farm losses in excess of the guarantee. The range of influence, therefore, is between zero earned income and the level at which payments dwindle to zero, which under the Family Assistance Program is $4,320 for a family of four. Nevertheless, for those farmers with some choice of enterprises there should be, over time, a slight shift to operations with more variation in prices or yields.

The fifth hypothesis is that an NIT program will induce migration of young individuals and families but retard migration of middle-aged people. Migration may be viewed as a risky enterprise and an income guarantee will reduce some of the uncertainty of moving to a new location. There is an opposing and perhaps stronger factor affecting the middle-aged family, however. NIT payments will allow some poor families to eke out a meager existence where they are. To the extent that the push effect of rural-to-urban migration is stronger than the pull effect, the nega-

[3] For a more detailed description of the experiment see [2].

[4] Figures are derived from Tables 22 and 25 in [10].

tive income tax should reduce migration of those already established in jobs or in farming.

Given the positive income elasticity for housing, a sixth hypothesis is that payments will increase short-distance movement of rural nonfarm renters and stimulate home improvements by low-income homeowners.

A seventh hypothesis is that borrowing will increase. While NIT payments, both in the experiment and in the Family Assistance Plan, cannot be garnisheed, they do provide lenders with some assurance of ability to repay. Thus a guaranteed income should open the door to small-scale borrowing by some of those to whom credit has previously been denied.

A final hypothesis is that a negative income tax program will encourage earlier retirement. This should have more impact on the self-employed who have greater control over when they retire than on wage earners who are often forced to retire at a certain age.

Status of Analysis

We shall wait until the end of the experiment to test some of these hypotheses, such as those relating to migration and retirement decisions, in an attempt to get enough observations of changes in status to make valid generalizations. Similarly we shall wait until after the second year to measure changes in farm organization, since the planning period for many crop and livestock operations is at least a year long.

We have just begun analysis of work behavior during the first year, but it is still in the preliminary and investigative stage. So far we have looked at only male heads less than 65 years of age with constant marital status over the first year and with all earned income from wages or salaries. Earned income of both the treatment and control groups has risen, but a comparison of relative changes is an appropriate indicator of the effect of payments on work behavior only if the control group is an exact replica of the treatment group. Obviously they are not alike, even though they were randomly drawn from the same population. It is necessary to use regression analysis or some similar technique in order to control for other intervening variables, such as education, sex, race, region, number of earners in the family, etc. Our regression findings to date are inconclusive. The magnitude of the treatment coefficient varies considerably, depending on the specification of the equation. In some cases it appears to be statistically significant; in others it does not.

If and when we do get consistent and reliable estimates for this first year they will be considered tentative because we believe that the first year's results are not likely to be a good indicator of labor supply response over the entire three-year period. It takes some time for families to adjust to the experimental setting. Low-income people are generally suspicious of government programs; and while we have attempted to disassociate ourselves from the government, it takes a while to convince them that we are actually going to make payments regularly with no strings attached. After this has been demonstrated the families must learn the operating rules of the program so they can begin to identify and assess their options within the experimental framework.

The operating rules were briefly explained at the time the families were enrolled and given their first check, and a more comprehensive written explanation was left with them. However, we began to feel that their level of understanding was fairly low, so after six months we asked them questions about program rules. The results were disappointing. For example, 25 percent erroneously thought they would be dropped from the program if they were fired or quit their jobs; 30 percent thought they would lose their eligibility if they moved out of the county; 54 percent did not know their basic guarantee within a 10 percent range; 57 percent did not know at what level of income their payments would be reduced to zero (again within a 10 percent range); 35 percent did not know that their earnings were taxed, and 90 percent of the North Carolina sample did not know their earnings were taxed or thought they were taxed at 100 percent.

Perfect knowledge is not a goal of experimentation; rather one hopes to duplicate the level of understanding that would exist under a national program. Nevertheless, it was our judgment that knowledge of the program was too low; so the operating rules were reexplained to every family.

For all of these reasons we view the first year's data with caution. The most significant behavioral responses will probably not occur until the second and third years of the experiment.

Some Administrative Problems

The NIT experiments have been designed primarily to measure behavioral responses; yet one of their more important contributions will be in identifying and solving administrative problems likely to arise in a nationwide program. The most important problem of this type in the rural ex-

periment involves the accounting procedure for calculating the level of payments each month.

Most families in the rural experiment are under a three-month moving average accounting period—monthly payments are based on the amount of earned income over the last three months.[5] But this procedure alone does not provide equal annual payments to families with differing income streams. For example, a farmer whose entire income is received in one lump sum during the year will, under a simple three-month moving average, receive more money than a wage earner with the same annual income distributed evenly throughout the year. There is a further complication in that some farmers and businessmen have negative net incomes in certain months, yet the monthly NIT payment is no larger when income is negative than when it is zero. Finally, a major expense for the self-employed, depreciation, is usually computed only once a year.

One alternative solution is to pay the self-employed a constant amount each month, based on their past year's income. This is unresponsive to the needs of most farmers since farm income usually fluctuates on an annual cycle; if it is perfectly cyclical, large payments based on the previous lean year will coincide with high income the following year. Such an accounting procedure only exacerbates the problem of cyclical annual incomes.

To circumvent such problems a procedure was developed for the rural experiment called the carryover method of accounting.[6] Quite simply it works like this: if net income in any one period exceeds the breakeven level (the point at which payments are reduced to zero), that amount over the breakeven level is assigned to the next period. If total income in the next period plus this assigned income also exceeds the breakeven level, the difference is assigned to the next period, and so on until current income plus the carryover falls below the breakeven level. Negative monthly income is also reflected in the carryover, and in fact the entire carryover sum can be negative. Since excess or negative income can be carried forward for up to 12 months, the accounting procedure ensures payment equity among farmers over any 12-month period. It is also more responsive to need in that farmers receiving income only once a year will not get payments in the months directly following receipt of that income; instead payments will come during the leaner months that precede receipt of income.[7]

Virtually all negative income tax programs, including the Family Assistance Plan, call for self-declaration of income by recipients. The frequency with which reports should be filed, and the documentation accompanying them, is a matter of no small concern. Monthly filing places a greater burden on the families and increases administrative costs; but it also shortens the recall period, thus minimizing forgotten income, raising reported income, and therefore reducing the amount of NIT payments. Requiring pay stubs from wage earners and receipts for major expenses from farmers has a similar trade-off between administrative cost and the degree of underreporting.

None of the four experiments treats frequency of reporting or the degree of documentation as an experimental variable.[8] However, some findings from the rural experiment do illustrate the importance of the problem. The payments group file monthly income reports and respond to a quarterly interview in which in-depth probing techniques are used to get at income and expenses over the past three months. Wage income from these two sources was compared for an eight-week period during the summer of 1970. North Carolina wage earners reported 17.6 percent less income on their income report forms than in the interview. A similar comparison for the Iowa sample, which has an average of four years more formal education, showed virtually no difference between the interview and the income reports.

Underreporting of income can be costly in a nationwide program. For example, underreporting of 17.5 percent under FAP would raise the cost of the program roughly 1.5 billion dollars.[9]

An interesting sidelight to this issue regards the question of how illiterates will function under a self-declaration system. The average educational level in the North Carolina sample is slightly less than eight years; 17 percent of the family heads cannot read at all, and another 34

[5] Payments to 75 families are based on the last month's income.

[6] For a detailed discussion of this concept see [1].

[7] The carryover method of accounting has since been incorporated in the current version (H.R.1) of the Family Assistance Act.

[8] A separate experiment has recently been proposed to measure the effects of these and other variables on reporting accuracy.

[9] This assumes an average annual reported income of \$3,000 per family, a tax rate of 66⅔ percent, and 3.6 million eligible families.

percent can read only with difficulty. Much to our surprise this has presented few problems. If the head is illiterate, someone else in the family (often the children) can usually read and write. Moreover, families with no literate member have already made arrangements whereby a friend or relative reads them mail, fills out government forms, etc. They rely on this person to aid them in filing our income reports.

The experiments have had to deal with many other administrative problems as well: how to reconstruct income histories for payment purposes when one member of a family leaves; how to handle reporting of depreciation and capital gains and losses by those to whom the terms are unfamiliar because they have never filed with the Internal Revenue Service; how to divide joint expenses on a monthly basis in order to categorize them as either personal or business expenses.

The positive income tax has never been particularly successful in dealing with the self-employed, and it appears that a negative income tax may encounter as much difficulty (but may result in fewer government dollars lost). For example, most people must file with IRS every year, whereas they will need only report to a FAP office when eligible to receive payments. This provides the self-employed with many opportunities for manipulating expenses and receipts to become eligible for transfer payments in any given 12-month period.

The Family Assistance Plan: Some Unresolved Issues

The impact of the Family Assistance Plan (FAP) on farmers is uncertain at the present time because so many important aspects with respect to coverage and administration are left to the discretion of the Secretary of HEW. Two of the most important of these involve limits on gross income and assets. With respect to gross income, the bill specifies that "the Secretary may prescribe the circumstances under which . . . gross income from a trade or business (including farming) will be considered sufficiently large to make such families ineligible for such benefits" [11]. This is presumably based on the assumption that there is a "normal" relationship between gross and net income common to all businesses and that setting a limit on gross income will reduce the possibilities of manipulating net income to become eligible for the program. The assumption of a normal gross/net ratio common even to all farming operations is a poor one.

Table 1 shows the relation of gross to net income for various types of farms for 1968. Net income as a percent of gross varies from a negative figure to 31.7 percent, depending on the type of farming operation. (A study of two other years of data suggests that 1968 is not atypical.) Moreover, the rank-order correlation between gross and net income in the table is a *negative* .14.

Establishing a gross-to-net ratio for each type of farm would also encounter difficulties. First there is the problem of identifying the type of farm. For example, in 1968 the relation of net to gross was 21.5 percent for tobacco farms, negative for tobacco-beef, and 19 percent for tobacco-dairy operations. Secondly, typical net/gross ratios for the same type of farm vary substantially among regions of the United States.

Finally, there is a definitional problem of whether the relationship of net to gross income should be computed before or after a return to capital is allowed. The figures below show dramatic differences between the two definitions for some farm types and much lesser differences for others.

	Before interest on investment	After 4 percent return on investment
Cash grain	43.2	negative
Cattle (northern plains)	53.2	3.8
Broilers	42.0	11.0
Dairy (New York)	43.0	28.7
Eggs	20.1	12.3

In summary, there seems to be no equitable way to establish a limit on gross income. If this provision of the bill is exercised, it will have discriminatory effects on some kinds of farming operations and could induce changes in enterprise mix by marginal farmers in order to get under the gross income limit.

Both the previous and current versions of FAP also specify that property "essential to the family's means of support" is to be excluded from the $1,500 asset limit, "subject to limitations prescribed by the Secretary . . ." [11]. Setting such a limit implies that assets *should* yield some specified rate of return; and if that imputed return is above the breakeven level for FAP payments, the farmer should be ineligible regardless of his actual net income. In other words, FAP should not aid farmers who have a bad year. This is analogous to denying benefits to a wage earner who unexpectedly loses his job; yet one of the purposes of FAP is to aid those in unfortunate cir-

cumstances until they become self-supporting again. A strict asset limit would discriminate against the self-employed vis-a-vis the wage earner.

As with the gross income limit, there are also inequities in applying one asset limit to all farming operations because of differences in the capital/labor ratio among farm types. Some examples of the rate of return on total assets are listed below:

	1968	1969
	percent	
Eggs	7.85	20.69
Tobacco and dairy	5.18	3.66
Tobacco	4.94	8.04
Broilers	1.79	2.46
Tobacco and beef	1.77	negative

The way this provision is applied by HEW will have important consequences for farming. Setting one overall asset limit will penalize capital-intensive operations as compared with labor-intensive ones. This should work to reduce the substitution of capital for labor on the part of low-income farmers near the asset limit. An asset limit will also provide an incentive to transfer ownership of farms in order to qualify for FAP payments, which is not unlike the consequences of the maximum limit recently imposed on farm program benefits.

There are other discretionary areas in the bill that have implications for farmers, such as how a part-time farmer will be regarded in terms of the work requirement and the type of accounting procedure used for the self-employed. It is sufficient to observe here that at the present time no other occupational group faces as much uncertainty as farmers with respect to implementation of the Family Assistance Plan.[10]

Before leaving this discussion of the Family Assistance Program it is appropriate to comment on its implications for traditional agricultural programs. FAP complements rather than competes with present farm programs, so its passage should not have important implications for the purpose or structure of current programs. It might, however, undercut some political support from those who mistakenly view farm policy as an anti-poverty tool. Secondly, FAP treats farm subsidies as unearned income and taxes them at 100 percent. Since there is some cost (in terms of foregone income) in becoming eligible for farm subsidies, many low-income farmers will not participate in commodity programs. This, however, should have only a marginal effect on the supply and price control objectives of farm policy.

Table 1. Relation of gross to net income for various types of farms, 1968

	Net income as a percent of gross	Gross income	Gross income ranking
Cash grain	negative	26,000	6
Tobacco and beef	negative	17,000	4
Cattle ranch (northern plains)	2.8	40,000	10
Sheep	3.7	49,000	13
Hog and beef fattening	8.2	49,000	12
Broilers	11.0	4,000	1
Eggs	12.3	34,000	8
Cattle ranch (northern rockies)	14.7	41,000	11
Tobacco and livestock (inner bluegrass)	17.6	21,000	5
Cotton	18.5	86,000	14
Tobacco	21.5	12,000	2
Dairy, Grade A (Wisconsin)	28.7	28,000	7
Wheat	29.5	34,000	9
Tobacco and livestock (outer bluegrass)	31.7	16,000	3

Concluding Remarks

One must conclude that at the present time we can make only educated guesses about the effects on rural people of a negative income tax program like FAP. This uncertainty is due partly to a lack of specificity in the current bill regarding treatment of the self-employed, but it is mainly due to a lack of knowledge about how poor people will react to the program. The rural negative income tax experiment was set up to provide this information; a year from now, when two years of data are available, we should be able to make some realistic predictions about the consequences of a national NIT program like FAP.[11]

[10] For a more comprehensive discussion of the Family Assistance Plan see [4].

[11] The Family Assistance Plan differs in many respects from the negative income tax experiment. Only families with children are eligible for FAP; there is a work and training requirement for those unemployed or underemployed; and the accounting system upon which payments are based will be different. Thus generalizing experimental results to the Family Assistance Plan is possible, but there are some limitations. For example, one might expect the degree of work disincentive in the experiment to be a maximum for FAP because of the latter's work and training requirement. If these requirements were fully effective, there would be no reduction in the supply of labor. Realistically, however, there will

Agriculture has long relied on experimentation to study plants and animals. Hybrid corn, optimum cattle rations, fertilizer mixtures, the green revolution (in fact virtually every technical change in agriculture) have all been preceded by careful experimentation. Social policy change, on the other hand, has been characterized by an absence of experimentation. Price supports, acreage allotments, import duties, manpower training, and rural area development programs have all been instituted with little knowledge about their consequences. Yet each could have been experimented with in advance of its adoption.

The negative income tax experiments are the first effort to use experimental information for social policy formulation. Let us hope we are now entering a new era in which experimentation with social policy alternatives will be considered as important as experimentation with technological innovations. If agricultural economists will begin to consider social experimentation as a research tool, we shall have a much more effective and cogent set of rural policies and programs in the future than we have had in the past.

probably be insufficient jobs and training slots for those on FAP who want them, so the work-training requirement will likely be ineffective in preventing voluntary work reduction. On the other hand, work disincentive under FAP may be larger than in the experiment since the latter will run for only three years; thus it may be regarded as a temporary program by the participants. For other problems in generalizing experimental results see [3].

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Discussion: B. EUGENE GRIESSMAN, Auburn University

Horvath's paper is original and interesting and casts the discussion within the framework of a basic theoretical prospective. As I understand it, the guaranteed annual income is treated as a form of income distribution, which is conceived as but one of several instances of government intervention in the pricing mechanism. A model is presented that is intended "to enable us to observe the working of grants economy," but it not clear whether the model is intended to be a practical analytical tool or a heuristic device. A quotation from Theodore Schultz, that "farm price supports predominantly benefit farm families who are well above the poverty line," is used to certify the author's contention that farm price supports are misapplied grants that benefit individuals or groups other than those for whom they were directly intended. Some analysts would argue that this program has squeezed out small inefficient units in American agriculture and thereby has helped make possible a more efficient agricultural operation overall.

I have mixed feelings about the author's contention that misapplied grants are at the roots of the prevalent inflation-ridden unemployment. Indeed, some grants do stimulate high prices by maintaining artificial scarcities. Some also tend to encourage unemployment; others reward inefficiency. But there are other culprits that deserve attention when one seeks out the main cause of the present "inflation-ridden unemployment." Two come to mind: (1) prolonged use of high interest rates which, when they did not deter borrowing, actually intensified inflationary pressures; (2) refusal of Congress to speedily impose a surtax when the economy began to overheat.

Bawden's paper reports the progress of a well-conceived evaluation of the impact of the negative income tax. Although he does not provide many specific answers, he does ask a number of good questions. On the whole, few fair objections can be raised about this experiment; the evaluation is needed, the design is sound, and the hypotheses are important.

Lyday's paper focuses primarily upon the political implications of the nationalized system of welfare. Hopes are now pinned on H.R.1, the Social Security Amendments of 1971. In summarizing the essential features of the measure, Lyday concluded that it "will not have any significant immediate economic impact anywhere in the United States"; but probably its early economic impact will be greater than Lyday predicts, primarily because dollars will flow into the hands of consumers, not savers. Although the total magnitude of the new expenditures will be somewhat small, at the microlevel each allotment will represent a substantial segment of the individual's total income. Furthermore, the measure provides a subsidy for an estimated 200,00 jobs in public service employment; if implemented, these jobs should affect the economy rather quickly.

Lyday's prediction is well-founded that the measure will have "revolutionary" consequences through a basic redefinition of who is entitled to an income. No longer would this be decided on the basis of age, disability, or whether a child is present in the home, but rather on the basis of whether the person is poor. The measure's provision for 100 percent federal funding and federal administration of a day care program also will have long-term consequences, for as time passes mothers other than those classified as poor will request day care services.

The argument that the bill would cause wage rates in the South to rise rapidly and thus increase the region's growth rates is not particularly convincing. No small part of the South's already accelerated growth during the past decade can be attributed to its comparatively low wages, a competitive advantage. A disproportionate rise of wages in the region might actually slow the movement of industry southward. That the bill would "facilitate the emergence of rational economic populism in that region, untainted by its traditional accompaniment of racism" is a promise too bright to be believed implicitly. Racial discrimination in the Deep South has more than an economic base; it is political as well.

Finally, the ultimate success of the bill, and of any measure designed to guarantee income, will depend upon the way it is collectively defined. In its present form, H.R.1 falls short of being a full-blown guaranteed income program, as the concept is commonly known, inasmuch as it calls upon recipients to register for employment. Even so, it may be seen as a move toward such a program, and this may cause reactionary forces to form. If the measure is seen as revolutionary—as a way to eat without working—widespread opposition is certain. But if it can be perceived as a work incentive measure that would enable welfare recipients to retain a portion of the income that they earn, massive political resistance would not be likely. This is because such a concept is consistent with a homely but cherished American value: A person who is willing to work deserves help.

POLICY ISSUES IN INTERNATIONAL TRADE AND ECONOMIC DEVELOPMENT

CHAIRMAN: ROBERT C. TETRO, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Domestic Farm Policy and International Trade*

H. S. HOUTHAKKER

OUR domestic farm policies have always been influenced by our position in international trade, although the nature of this influence has varied over time. In those crops where we are normally net exporters we have gradually moved from a policy of export subsidies to one of bringing domestic and export prices closer together, while in those farm products where there is competition from imports we have increasingly attempted to keep domestic prices above world prices. This bifurcation can of course be cited as an example of the mercantilism that continues to dominate practical economic policies both here and abroad. However, this cannot be the whole story, if only because international trade is only one of the several factors that shape farm policies. It is precisely this interplay of domestic and external considerations that is our subject at this session.

My reference to mercantilism may seem facetious to those of you who know all the theoretical arguments against it. The unfortunate fact of the matter is that mercantilism *is* the philosophy from which most protectionists and quite a few free traders draw their inspiration. Businessmen are generally more interested in selling than in buying; the idea that free trade is good for consumers because it enables them to get more value for their money holds little charm for producers or for the many legislators and administrators who usually take the producers' point of view. It is probably true, as an economist pointed out recently, that the Japanese with their cheap cars and TV sets have done vastly more for the American consumer than Ralph Nader and his cohorts, but we would never guess it from the vehemence with which people in authority now denounce Japan's export surplus (and I hasten to add that Japan's foreign economic policies are indeed open to serious objections). The temporary existence of considerable unemployment lends mercantilist policies a superficial attraction in present conditions.

Quite apart from its other weaknesses the main difficulty with mercantilism in practice is that it leads to contradictions that can be resolved only by political means, if at all. If countries with a comparative advantage in a commodity use subsidies to push their exports and importing countries attempt to protect their own producers of that commodity, the equilibrating mechanisms of economics become powerless.

This is the problem we ran into during the 1960's. Despite Secretary Benson's efforts we followed essentially a policy of high farm prices until the 1965 Agricultural Act. Our prices for wheat, cotton, and other field crops were generally so high that we could not sell on the world market without subsidies or give-away programs. This policy was sustainable as long as foreign production was held down by the aftereffects of the war, but not much longer. Even in its heyday this policy led to such absurd results as our selling cotton at a higher price to our own textile mills than to their competitors abroad, thus inflicting lasting damage on our textile industry.

As we all know, there were other and perhaps even more compelling reasons for moving from a policy of high support prices to a policy of direct payments for the basic field crops. High prices led to overproduction, since there were no effective ways of curtailing output. The resulting excess inventories stimulated public demands for reform. Moreover high farm prices are not an efficient way to support farm income, especially after steady growth in purchases of farm inputs made gross receipts less and less indicative of net revenue. Provided that they are suitably designed, direct payments make a more immediate contribution to farm income than high product prices.

Although the switch from high support prices

* The author is greatly indebted to Gary Seevers for his help in the prepreparation of this paper but is solely responsible for its contents.

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to direct payments was a considerable step forward from the economic point of view, it had political disadvantages. The economist can show without much difficulty that if a pressure group asks for special consideration the best way to do this (that is, the way that causes less distortion in the allocation of resources) is to give them money rather than let them cut output in order to raise prices. In many cases, however, the pressure group does not want to be identified as the beneficiary of federal largess. Although artificially high prices do distort allocation of resources, they make the benefits harder to identify. Under the old system of high support prices, for instance, a certain amount of research is needed to show that a disproportionate share of the benefits goes to the larger producers.[1]

There was no great outcry over the distribution of benefits during this earlier period, but now that we have direct payments the subject is much more in the public eye. As a result a payment limitation to $55,000 was included in the 1970 Agricultural Act, and a further limitation to $20,000 was narrowly defeated just recently. Actually the present payment limitations are very easy to evade, and the attempts of Congressman Findley and others to put teeth in them have not so far been successful. If the direct payments of current legislation were purely income supplements this would be regrettable, but they also serve to encourage participation in the set-aside, so that strict enforcement of payment limitations might actually undermine the existing method of controlling supply.

This leads to the question whether there really is a need for such supply controls at the set-aside, the principal innovation of the Agriculture Act of 1970 and itself an improvement over the acreage controls and diversion provisions of earlier legislation. In principle the task of adjusting output to consumption could be done through the pricing process, possibly supplemented by limited government intervention to counteract the excessive fluctuations sometimes found in speculative markets. Primary reliance on prices, with payments to augment farm income, was in fact the original intention of the Nixon administration's approach to farm policy, and the set-aside was thought of as a safety valve that might be needed during the transition to a freer market. But this approach required greater freedom of pricing than the Congressional committees on agriculture were willing to allow. Despite the unanimous evidence to the contrary from a vast amount of research by agricultural economists, many politicians still believe in the myth of negative supply elasticity for farm products and consequently do not accept prices as an adjustment mechanism. In Congress there also remains much sympathy for another relic of the 1930's, the price parity concept. Strict limitations on the Secretary of Agriculture's discretion with respect to support prices were therefore written into the farm bill, thus making the set-aside correspondingly more important as an adjustment device.

Let me add a few words at this point about the 1970 farm bill in general.[2] As Samuel Johnson said about the dog that could dance on its hind legs, one should not ask whether it was done well; the remarkable thing is that it was done at all. The conditions for getting acceptable farm legislation in 1970 were anything but favorable. To begin with, there was a time bomb in the background; the 1965 Act would be superseded on December 31, 1970 by the 1958 Act which contained a number of very bad provisions, especially for cotton. The progress made during the 1960's towards a more liberal farm policy would thus be reversed. Surpluses that were at last being worked down would soon be with us again; and farm income, no longer supplemented by direct payments, would fall. Very few people wanted a return to the 1958 Act, but it was used effectively as a threat. A mere extension of the 1965 Act was not in the cards either; it severely restricted farmers' freedom to plant and the question of payment limitation was one about which the agricultural committees disagreed sharply with the House and Senate as a whole. In fact this disagreement extended to other aspects of farm policy; the House in particular had frequently shown itself more inclined to reform than its Agriculture Committee. Since any farm bill had to pass both the Committee and the House as a whole, this did not leave much room for maneuver.

The Administration was anxious to reinforce the role of the free market in agriculture, but it was not committed to any particular approach; farm policy had not been an issue during the

[1] Since I have occasionally been misrepresented as a proponent of corporation farming, I may be permitted to point out that my article, "Towards a Solution of the Farm Program" [2], was one of the first places where calculations were presented and remedies suggested.

[2] For a more extensive discussion and evaluation see Carter and Seevers [1].

1968 presidential campaign. The major farm organizations of course had their positions, but these were so diverse as to cancel each other out. The American Farm Bureau Federation advocated large-scale land retirement and the abolition of direct payment, but neither of these proposals appeared to be based on any clear-cut analysis of the problems facing American farmers. There was also a question about the extent to which the Farm Bureau's national leadership could speak for its many members or even for its state organization. The National Farmers Union advocated extension of the 1965 Act with some modifications. Neither of these groups had much influence on the final bill, which passed despite their opposition; only the Grange gave it belated support.

The 1970 Act, as it emerged from lengthy and sometimes heated deliberations, does not come as close to a freer farm economy as the Administration had hoped, though it does give farmers a great deal more leeway than the 1965 Act. It does represent a further step, albeit a small one, toward a more rational farm policy, one that takes full account of the true interests of farmers, consumers, and taxpayers. In this respect it is far superior to the farm policy practiced by certain other countries, especially those constituting the European Economic Community.

Presumably there is no need in this gathering to explain the Common Agricultural Policy of the EEC, nor to enlarge on its deficiencies.[3] We in the United States bear some responsibility for its adoption, in part because its conception owes much to our own legislation of the 1940's and 1950's and in part because during the Dillon Round of tariff negotiations (1960–1961) we acquiesced in the variable levy, which is an indispensable element of the CAP. Results of the CAP to date have confirmed the warnings of its critics. The cost to European consumers has been very large, the disruptive effect on international trade considerable,[4] and the benefits to European farmers uncertain at best. Nevertheless the CAP continues more or less unchanged; the EEC, torn by internal dissension and lacking an effective parliament, has generally been unable to reconsider its policies in the light of experience. There had been some hope that the accession of the United Kingdom and three other countries might be the occasion for revisions of the CAP, but the British chose instead to swallow the CAP hook, line, and sinker. At the moment the main threat to the CAP is from the monetary side, since it is difficult to reconcile with changes in par value or with floating rates. In fact some EEC countries have been forced to adopt direct payments to farmers, a technique contrary to the spirit of the CAP and previously held infeasible under European conditions.

While we have ample reason to complain about the CAP, it should not be thought that our own record in international agricultural trade is without blemish. Our policy with respect to the major temperate zone field crops has become more liberal in recent years; thus the virtual abandonment of export subsidies under the present Administration deserves mention as an important achievement. The revival of the cotton futures market is also a sign of health. But all this occurred in crops in which we happen to have a comparative advantage. When we move to farm products where our domestic producers have to compete with imports the picture is much less bright.

There are three major programs of quantitative restrictions in agricultural imports: dairy products, meat, and sugar, not to mention some minor ones such as the so-called size limitation on tomatoes. Perhaps the most harmful of these is the sugar program, which is now in the process of being extended for another three years. It is also the most complicated, and that is why I shall confine myself to three general comments:

1. The need for a separate sugar program is not clear, since any protection the domestic industry may be entitled to (and I believe it gets far more protection than the public interest requires) could be provided under existing general legislation.
2. To the extent that sugar quotas can be justified as a form of foreign aid they appear to be a case of "poor people in rich countries giving money to rich people in poor countries."
3. The continuation of this program for so many years is attributable mostly to the failure of consumer groups to assert their interests.

Like the sugar program, the dairy import restrictions go back a long time. They are a byproduct of the dairy price support program

[3] For a more detailed discussion see Houthakker [3, ch. 5].

[4] Thus the breakdown of the International Grains Arrangement (not that it was any great loss) can be attributed in large measure to the dumping of surplus wheat by the EEC in third countries.

which has not had the same attention from reformers as the support programs for fieldcrops. There are no direct payments for dairy farmers, and the price level has been kept so high as to lead to a sharp fall in per capita consumption. The industry still consists preponderantly of small farms. In 1969 more than half of the dairy farms had fewer than 10 cows, and less than one-tenth had over 50 cows. While these figures represented significant improvement over 1964, they suggest that many of our dairy farmers have a long way to go before they reach the efficiency of New Zealand where nearly all commercial dairy farms have at least 50 cows, which no doubt helps make New Zealand the low-cost producer in the world.

Whatever our dairymen may lack in economic efficiency they make up in political know-how. The first provision of the 1970 farm bill on which agreement was reached (with very little debate) was an extension of the Class I Base Plan for milk, one of those clever schemes for getting rich by producing less that are always popular with industry groups. The Class I Base Plan in fact aims at milking consumers rather than cows, although so far its application has fortunately been restricted. In addition, some dairy cooperatives under cover of the agricultural exemption in the antitrust laws have been trying for some time to stifle competition by the organization of so-called superpools. Perhaps the greatest achievement of the dairy politicians came this spring when they managed to have the Secretary of Agriculture overruled on an initial decision to leave the milk support price unchanged. After a slush fund (the Trust for Agricultural Political Education) had made contributions totalling some $100,000 to various campaign committees, the support price was raised by about 6 percent. Without going into the ethics of this transaction it is interesting to note that this price increase is likely to transfer hundreds of millions of dollars from consumers to dairymen, so that the political contribution was a splendid investment from the donor's point of view. It is less clear that, at a time when inflation is a major campaign issue, this deal is also advantageous to the recipients. A better price performance in 1972 may well be a more potent persuader than a few additional minutes of television time.

Imports of dairy products have been a particular concern of the industry's spokesmen. Although imports were equivalent to only 1.5 percent of domestic production during the last three years, great efforts have been made to prevent evasion of the quotas by the introduction of new products. This matter is of particular importance to our trade policy because the EEC is an exporter of dairy products and has often complained about our restrictions. In fact the only conceivable compromise that would improve the CAP presumably would involve liberalization of dairy quotas on our part. Unfortunately neither side appears to be ready for such a compromise at present.

Meat is another commodity for which we fail to practice the liberal trade policy that we preach for our exports. Under the 1964 Act imports of beef and mutton are subject to restrictions, but the President can suspend the quotas and has in fact done so because of high domestic meat prices. These meat quotas in practice have been of the "voluntary" type, under which the exporter captures the difference between the U.S. price and the world price. There is a real question, quite apart from the impact on consumers, whether the world meat situation justifies restrictions of any kind. The bulk of the beef imported into the United States is used for manufacturing; it fills the gap left by the declining slaughter of dairy cows, the principal domestic source of low-grade beef. Our own cattlemen have long specialized in high-grade table beef, in which the United States remains competitive. Moreover, even in manufacturing beef there is no persistent world surplus; until 1968 the law did not have to be invoked at all, and currently there is some doubt whether the principal supplier (Australia) can fill its quota. As part of a multilateral reduction of agricultural trade barriers we could put our meat quotas into the negotiation without significant damage to domestic producers.

Unless we are prepared to reduce our own import restrictions we are not likely to make much progress in getting other countries to reduce theirs. Free trade is a two-way street; it deserves support not primarily because it is good for exports but because the ultimate purpose of trade is to obtain imports. As economists it is our constant duty to remind the body politic of these elementary facts and to develop policies that are in accordance with them.

The only domestic farm policy that is consistent with reasonably free trade and a minimum of government interference is one where (1) prices are realistic, in the sense that, taking one year with another, they bring supply and demand into balance; and (2) the incomes of farm-

ers are supplemented, if that is considered desirable for social or political reasons, by direct payments that do not significantly distort production or consumption decisions. This is the policy to which we have been gradually moving for our export commodities. If such a policy had been applied more widely, both by us and by our customers abroad, we would have gone a long way towards conformity of world agricultural trade patterns with the public interest.

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Discussion: HOWARD L. WORTHINGTON, Foreign Agricultural Service, USDA

Most of us I am sure can agree with Houthakker that our goal should be to move toward freer trade and away from protection. Few of us would disagree with his statement that unless we are prepared to reduce our own import restrictions we are not likely to make much progress in getting other countries to reduce theirs, if this is understood to apply to a new major multilateral negotiation. But these two statements come at the end of Houthakker's remarks and may lead one to believe that the way to deal with the Economic Community's Common Agricultural Policy and agricultural production is to liberalize or remove U.S. barriers on dairy products, meat, and sugar and that a satisfactory settlement of our agricultural questions is possible in the agricultural sector alone if only the United States will set the proper example.

I am highly skeptical of the value of good examples in the field of agricultural trade. On sugar, for example, for years the United States has allocated 40–45 percent of its domestic consumption to foreign suppliers, a market share that U.S. producers wouldn't mind keeping for themselves. In recent years, however, the European Community has become a net exporter, with export subsidies and without effective production controls. On beef, until the middle 1960's the United States was an excellent example of liberalism, with no price supports, no import quotas, and a very small tariff. Nevertheless, Japan kept its restrictions and the Community constructed an import control system, and we have followed this bad example. On dairy products, until recently a wide range of cheeses and other dairy products were permitted unrestricted access to our markets, with the result that the United States has become a dumping ground for butterfat that could find no other home in a world where all other major markets were controlled.

Houthakker points out rightly that we have been moving away from export subsidies. Yet every day brings a new subsidy from the European Community. Just last week, for example, I was informed that the Community had extended its subsidies on tomato products to the Canadian market which is one of the few foreign markets for this product that remains to our producers. Situations like this certainly strengthen the hands of those who argue that there is no longer any alternative but to fight fire with fire.

In the longer run I think there is no question but that, as Houthakker has said, we must be prepared to further reduce our own import restrictions if we are to make progress in getting other countries to reduce theirs. But to reach this goal we must insist that our trading partners live up to the trading rules and concessions we have already paid for. And even in the long run a multilateral negotiation won't work in agriculture alone; nor will it work except on a truly grand scale. Any new multilateral negotiation for further reduction of barriers must include at a minimum both industrial and agricultural trade barriers, and perhaps even more. The effort must be a major one, of sufficient size and daring to capture the imagination of the world's leaders to make it possible for them to take the necessary but unpopular decisions required in agriculture and elsewhere.

The recent decision by the OECD to establish a high-level group to look into these questions may have already launched us in this direction. However, we should not let the prospect of a major negotiation some time in the future distract us from things to be done in the short term.

There already exists a network of rights and obligations negotiated in past years in the General Agreement on Tariffs and Trade. We cannot afford to ignore them. For example, regarding the enlargement of the European Community, we face the tasks of ensuring that the enlargement arrangements conform to the GATT and of moving ahead with the necessary work looking toward GATT negotiation to conform the existing EC and applicant country tariff concessions to the new situation that will exist after enlargement takes place. Specific and general GATT rights exist that must be protected and used to enhance our trading position. In all of these efforts we cannot overlook the links between domestic farm policies and international trade.

Whither Aid?

S. R. Sen

I have been asked by your president, Professor Hillman, to share some of my thoughts with you today on the subject, "Whither Aid?" with special reference to the situation in this country. Professor Houthakker has spoken to you about trade and Dr. Wells has discussed the related subject of international agricultural adjustment. This interest on the part of the American Agricultural Economics Association in the international problems of aid, trade, and economic development is indeed very appropriate and timely, because the world has just entered what the United Nations has designated as its Second Development Decade and the President of the United States has only recently given a call for a new orientation in this country's approach to aid, trade, and economic development.

According to a recent estimate, in spite of all that can realistically be done to promote family planning, the number of able-bodied workers in the developing (or less euphemistically speaking, poor) countries is likely to increase from 662 million in 1970 to 829 million by 1980, an increase of about 25 percent. Considerable misery and social unrest (with serious potential for trouble for the rest of the world) can be avoided only if they can be provided with prospects for suitable employment and a reasonable increase in their per capita real income, which is today unduly low and a very small fraction of that of their counterparts in developed (or rich) countries. This will be possible only if the modest GNP growth target of 6 percent per annum set for the Second U.N. Development Decade, which is barely 1 percent higher than the rate already attained, can be achieved. But that means that the developing countries should be able to increase their imports from the developed countries, so essential for growth, by a little under 7 percent per annum, their exports to the latter by a little over 7 percent, and receive capital and technical transfer (or aid) at the rate recommended by the United Nations, viz., 1 percent per annum of the GNP of the developed countries [5].

But precisely at this juncture there is a growing pressure from certain influential circles in the United States, which pioneered both liberal trade and aid policies after World War II and continues to be the world's richest and biggest trading nation, for restricting both imports from and aid to the developing countries. The irony of the situation is that just when the other developed countries have started moving in the direction that the United States itself not only preached but also practiced in the fifties and early sixties, powerful sections (including organized labor, which was relatively liberal earlier) in the country should be advocating just the opposite course. It goes without saying that if the developed countries import less from developing countries, their aid to the latter would have correspondingly to go up (or vice versa) if the development objectives and related imports of the developing countries are to remain unimpaired. "Whither trade?" is therefore a relevant question when one is considering "whither aid?" But I shall leave the question of trade to others and concentrate on aid, as I was asked to do.

Whither Aid?

A brief but candid answer to this question is that it is declining for the United States and rising for most of the other developed countries in terms of both quantity and quality. Only a few years back the aid given by the United States was the highest, both in total volume and as percentage of GNP. Today it continues to be the highest in terms of volume but stands at a significantly lower level in terms of percentage of GNP. The flow of official resources to the developing countries from the United States has declined from \$3.72 billion in 1967 to \$3.29 billion in 1970 (without counting the fall in the value of the currency) but has increased from \$4.36 billion in 1967 to \$4.66 billion for other developed countries that are members of the D.A.C. (Development Assistance Committee). The difference in trend is even more striking if one combines official and private flows. These declined from \$5.64 billion to \$5.46 billion for the United States and increased from \$5.67 billion to \$9.41 billion for other D.A.C. countries between 1967 and 1970 (see Table 1). In terms of proportion of GNP, the United States today stands below 11 other D.A.C. countries if only official flows are counted and 15 other D.A.C. countries if both of-

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Table 1. **Flow of financial resources from all D. A. C. countries[a] (and United States separately) to developing countries and multilateral institutions, 1966–1970[b]**

	1966	1967	1968	1969	1970*
			billion U. S. dollars		
Net disbursements					
Total, official and private	10.35 (4.88)	11.31 (5.64)	13.19 (5.72)	13.75 (4.65)	14.87 (5.46)
Total official	6.52 (3.52)	7.08 (3.72)	7.14 (3.61)	7.28 (3.33)	7.95 (3.29)
Official development assistance	6.14 (3.48)	6.69 (3.26)	6.41 (3.05)	6.70 (2.83)	6.74 (3.12)
Grants[c]	4.28 (2.26)	4.39 (2.02)	4.10 (1.73)	4.38* (1.55)	4.30 n.a.
Loans and other long-term capital	1.86 (1.23)	2.30 (1.24)	2.31 (1.32)	2.32* (1.29)	2.44 n.a.
Other official flows	0.38 (0.07)	0.40 (0.16)	0.73 (0.30)	0.59 (0.17)	1.21 (0.17)
Total private	3.83 (1.36)	4.22 (1.92)	6.06 (2.12)	6.47 (1.32)	6.92 (2.18)
Direct and portfolio investment	2.70 (1.29)	3.22 (1.86)	4.46 (2.08)	4.72* (1.30)	4.69 (2.12)
Private export credits	1.12 (0.68)	1.01 (0.62)	1.59 (0.35)	1.75* (0.20)	2.23 (0.05)
			percent		
Volume indicators (net disbursements)					
Total flow as share of GNP	0.71 (0.64)	0.73 (0.70)	0.79 (0.65)	0.75 (0.49)	0.75 (0.56)
Total official flow as share of GNP	0.45 (0.46)	0.46 (0.46)	0.43 (0.41)	0.40 (0.35)	0.40 (0.34)
Official development assistance as share of GNP	0.42 (0.45)	0.43 (0.44)	0.38 (0.38)	0.37 (0.33)	0.34 (0.32)
Private flow as share of GNP	0.26 (0.18)	0.27 (0.24)	0.36 (0.24)	0.36 (0.14)	0.35 (0.22)

[a] Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Sweden, Switzerland, United Kingdom, and United States. Figures for United States are also shown separately within parentheses.
[b] Items may not add to totals due to rounding.
[c] Including "grant-like" flows denominated in recipients' currencies and contributions to multilateral institutions.
* Preliminary.
Source: International Bank for Reconstruction and Development.

ficial and private flows are counted [4]. Compared to the target of 0.70 percent of GNP for official flows and 1 percent of GNP for both official and private flows recommended by the United Nations, the figures for the United States were respectively 0.34 percent and 0.56 percent in 1970, which represented in fact a sharp decline from the figures of 0.46 percent and 0.70 percent recorded in 1967. It may be worth noting that as many as seven other D.A.C. countries have already reached the U.N. target of 1 percent of GNP for total flows, the average for all D.A.C. countries being 0.75 percent. As regards the quality of aid, seven other D.A.C. countries have a higher proportion of grant element than the United States.

In the United States itself there has been a considerable hardening of the terms of aid over the last decade; the proportion of grant equivalent to total aid has declined from over 96 percent in 1960 to less than 60 percent in 1970. There was a much larger proportion of grant element in Marshall aid, which went to the developed countries of Europe as quick disbursing "program aid," than in current economic aid which is going to the developing countries largely as slow disbursing "project aid."

There are several reasons why the recent performance of the United States in the field of aid has been so disappointing and out of line with its earlier precept as well as practice. The burden of the Vietnam war and the balance of payments difficulties are certainly two of these. But the target of economic aid from the United States in terms of the U.N. resolution is such a small fraction of her annual public revenue as well as foreign exchange earnings (and recently she has been able to step up certain other types of expenditure so much) that these two reasons do not appear to be conclusive.

One cannot help feeling that the basic reason is the lack of political will among U.S. authorities. For a country that has been taxing more than 25 percent of its GNP for public purposes, has made extensive use of public finance measures for transfering income from the richer to the poorer sections of its own citizens, and has learned over the years that such transfers instead of impoverishing the country have been in practice quite commensurate with a progressive increase in its per capita GNP, it is difficult to believe that it cannot do what some other less rich developed countries have already done, viz., set aside 1 percent of the GNP for purposes of economic development of poor countries. It is by no means an unduly high figure. The U.S. Government itself has accepted it in the United Nations, although with certain qualifications. One is therefore led to

the conclusion that what is really standing against its being implemented in practice is basically the lack of political will that I mentioned earlier.

The question follows: Why is there this lack of political will in the United States in contrast with the position in certain other developed countries today or even with the position in the United States itself during the fifties? Sometimes it is said that it is because of disappointment with the results achieved in the aid-receiving countries. But the fact stands that during the last decade the developing countries in receipt of aid have been able to increase their GNP on the average at a rate faster than not only what they themselves had achieved in the earlier decades but also what most of the developed countries themselves experienced when they were at a similar stage of development. And this has been very largely based on their own resources. Further, the trade of developing countries with developed countries has gone up substantially as the GNP of the former has gone up.

Sometimes a contrast is made between the achievements of Marshall aid in the European countries and economic aid in the developing countries, but this is not quite fair. The skills and institutions had already been developed in the European countries; all that needed to be built up for reconstruction were certain physical facilities. But the developing countries have to build up both physical facilities and skills and institutions. If it takes 3 to 4 years to build a factory, it takes 10 to 15 years to develop an engineer or a countrywide communication and marketing system. Further, per capita aid was much greater, terms of aid much softer, disbursement methods much quicker, and controls much less detailed and stringent under Marshall aid to European countries than for economic aid to the developing countries.

Sometimes it is said that the developing countries have not become politically responsive to the extent expected of them. Within the national system no one says that public finance operations that transfer some income from the rich to the poor can be justified only when there is a direct quid pro quo in terms of political response. Then why be so surprised and uncooperative when the response of the poorer countries is basically no worse than that of the poorer citizens of your own country? The goal and the means remain valid.

In my view the main problem for the United States seems to be that aid was sought in the first instance to be "sold" to the people as a business deal with direct quid pro quo and not regarded as a public finance exercise justified in objective terms of social responsibility, as has been done by certain other D.A.C. countries. Further, the usual experience that overoptimism is almost inevitably followed by overpessimism is applicable to the American aid program. It may take a little longer time but in future it will be better to get the aid target of 1 percent accepted as a social responsibility of the public finance type rather than a business deal associated with attractive bargains and direct quid pro quo.

The disappointment with aid in the United States has been paralleled by a corresponding disenchantment with aid in some of the developing countries. The delays and distortions introduced in their own programs by the aid-giving process and the much harder terms of economic aid as compared with Marshall aid have reduced considerably the attraction that some of them had earlier for aid.

Amount of Aid

As regards the amount of aid, although there may be a case for a somewhat higher figure than the 1 percent of GNP target agreed to by the United Nations, I feel that for practical reasons it will be better to stick to this generally accepted figure at least for the present. It will be just sufficient for achieving the growth target of the Second Development Decade, provided that the supporting trade and other economic policies are effectively implemented at the same time.

Within this overall figure, however, I would venture to suggest two basic changes. First, the aid target and its actual implementation need not be related to each other on an annual basis in a routine manner. Instead there should be a firm requirement that they must fully match over a quinquennium or so. This would introduce a useful flexibility and at the same time rule out some of the usual alibies for nonperformance. Second, 0.70 percent of GNP, which is the figure for official aid, should be in its entirety nonrepayable grant so far as the national exchequer is concerned. But all of this amount need not be passed on as grant directly to the recipient developing countries themselves. It may be appropriately transferred in the first instance to certain development finance institutions, either international, e.g., the World Bank group (I.B.R.D., I.D.A. and I.F.C.) or national, e.g., the two new U.S. aid organizations (I.D.C. and I.D.I.) recently

Table 2. External public debt outstanding (including undisbursed) and debt service payments of 80 developing countries, by region[a]

Region	Debt outstanding 12/31/69	Debt service payments, 1969	Average annual rate of growth: Debt outstanding 1/1/56–12/31/60	Debt outstanding 1/1/61–12/31/69	Debt service payments 1956–1960	Debt service payments 1960–1969
	million dollars		*percent*			
Africa	9,184	725	6	13	32	13
East Asia	7,609	436	21	17	14	17
Middle East	4,883	475	13	13	31	5
South Asia	13,809	705	33	17	52	19
Southern Europe	6,228	532	16	13	42	8
Western Hemisphere	17,618	2,183	11	11	27	6
Total	59,331	5,055	14	14	29	9

[a] Includes 80 countries as follows:

Africa: Botswana, Burundi, Cameroon, Central African Republic, Chad, Democratic Republic of Congo, Dahomey, East African Community, Ethiopia, Gabon, Ghana, Guinea, Ivory Coast, Kenya, Lesotho, Liberia, Malagasy Republic, Malawi, Mali, Mauritania, Mauritius, Morocco, Niger, Nigeria, Rhodesia, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, United Arab Republic, Upper Volta, and Zambia.

East Asia: China, Indonesia, Korea, Malaysia, Philippines, Singapore, and Thailand.

Middle East: Iran, Iraq, Israel, Jordan, and Syria.

South Asia: Afghanistan, Ceylon, India, and Pakistan.

Southern Europe: Cyprus, Greece, Malta, Spain, Turkey, and Yugoslavia.

Western Hemisphere: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela.

Source: International Bank for Reconstruction and Development.

proposed by President Nixon [6]. These institutions should have the authority to pass on the funds to the developing countries either as grant or as loan, depending on the requirements of each case. The result will be that while the part given as grant will not be repaid the part given as loan will be repaid over a period and will help to form an ever-increasing revolving fund, with the potential of becoming in course of time a very powerful instrument for international transfer of capital not only between the developed and developing countries but also between the developing countries themselves. This revolving fund could be augmented very substantially (and with minimal burden on the taxpayers of the developed countries) if the debt service payments on outstanding official loans owed by developing countries (see Table 2) were credited to these finance institutions instead of going back to the exchequers of developed countries.

Annual appropriations of grants out of the general revenues of a donor country sometimes lead to practical difficulties. If the amount of foreign aid grants could be somehow related to the import duties (especially protective duties) or to duties on articles like cigarettes or liquors, the consumption of which is considered to be of a luxurious or harmful nature, the opposition to such grants might be significantly reduced. A linking of foreign aid grants to the level of import duties will have the added advantage that the need for the former will be less when the latter is lower (and access to the market is greater) and vice versa. Domestic adjustment policies may also then get the much needed priority over tariffs and other protective devices in the developed countries. This aspect has a topical relevance now when there is a general increase of import duties in this country, without any indication yet of a generalized preference in favor of developing countries as recommended by the UNCTAD and accepted in principle by the U.S. Administration. The case for such a preference has become stronger now because the present troubles of the United States have originated not in the developing countries but in the developed countries.

In considering what is the appropriate amount of aid attention must be paid to both the benefits resulting from aid to recipient countries and the burden imposed on the taxpayer of aid-giving countries. A great deal of unfortunate misunderstanding has been created by describing what are no more than commercial transactions, e.g. loans, as aid. An attempt is sometimes made to measure concessional elements in development

Table 3. Trade gap projections for 1975 and 1980 for developing countries[a] (in billion dollars at 1960 prices)

	1963 Actual		1975		1980	
	I[b]	II[c]	I[b]	II[c]	I[b]	II[c]
Exports						
Goods	31.8	24.3	65.2	43.0	92.4	51.0
Services	5.8	5.4	12.2	10.8	17.3	14.7
Total	37.6	29.7	77.4	53.8	109.7	65.7
Imports						
Goods	32.0	28.9	67.5	58.2	93.8	78.8
Services	5.5	4.4	13.0	10.5	18.0	13.6
Total	37.5	33.3	80.5	68.7	111.8	92.4
Export/Import gap	0.1	3.6	3.1	14.9	2.1	26.7
Factor income payments (net)	4.9	2.3	15.8	7.5	23.7	10.8
Trade gap	4.8	5.9	18.9	22.4	25.8	37.5

[a] Provisional.
[b] Relates to all developing countries, the combined rate of growth of which averages 6.1 percent per annum.
[c] Excluding petroleum exporting countries.
Source: UNCTAD Secretariat, Document No. TD/B/264/Rev. 1.

loans by calculating the grant element, as is being done by the D.A.C. But even such an exercise does not tell the whole story. The opportunity cost of capital is not the same in all recipient and donor countries and the use of a single discount rate conceals the fact that the cost to the donor is often much less than the benefit to the recipient. Aid-tying and other restrictions placed on the use of aid funds also reduce their value to the recipient considerably. Related to this is the practice of clubbing military or national security aid together with economic aid. This has not only led to a confusion of objectives but also created a wrong impression in the public mind about the specific burden on the taxpayer of the latter. Strictly speaking, security aid (the bulk of which is either payment for services rendered or surplus disposal of defense material) should be considered part of defense expenditure.

A concerted effort to explain these various elements properly to the citizens in developed countries would go a long way towards winning their support for continued and enlarged aid effort. Equally, it would remove some of the misgivings in the developing countries who are sometimes asked to believe that even commercial transactions are aid.

These points are relevant particularly to the figures of U.S. aid that are commonly mentioned in public discussions here. They usually overstate both the burden imposed on U.S. taxpayers and the benefits derived by recipients of U.S. economic aid. The point also needs to be noted that the burden of aid ultimately borne by the U.S. taxpayer does not all benefit the developing countries. A considerable part of the benefit goes as transfer income to certain groups in the United States itself through various aid-tying devices.

The decline in net aid (and inadequate improvement in terms) has created a serious debt-servicing problem for many developing countries [3], a problem further compounded by the fact that while in the ultimate analysis the developing countries can make repayments only out of their export earnings there is not yet the reduction in the tariff and nontariff barriers against their exports and the adjustment in production structure in the United States and most other developed countries that would facilitate an increase in these export earnings. It is in the context of debt servicing, import requirements, and export earnings that the questions of aid and trade become closely interrelated (see Tables 2 and 3). If international transfer of capital and technology, so essential for economic development, has to be self-generating and not dependent on the transient moods of governments and legislatures, it has to be increasingly financed by export earnings of the developing countries, which means that the trade and adjustment policies that the developing countries have been pressing for in the UNCTAD deserve an even higher priority than aid policies inasmuch as grants are limited by budgetary constraints in the developed countries and loans are limited by the repayment capacity of the developing countries.

Type of Aid

Aid may be provided in terms of free foreign exchange, inconvertible currency, commodities, and technical services. The more convertible the form, the more economic and better in terms of quality it is likely to be. It has been estimated that in terms of real value, aid in inconvertible currency may be sometimes worth 30 to 35 percent less than aid in free foreign exchange from the standpoint of the recipient countries. The real value to them of commodity or service aid may in some cases be even lower. On the other hand, the opportunity cost of providing aid may be substantially lower for aid tied in terms of currency or commodity or services if there is balance of payment difficulty or excess capacity in the donor countries [1].

What would be the best combination from the standpoint of both recipients and donors would vary from case to case. While tied aid may not be avoidable, whenever it is given it is best not to express its worth in terms of nominal value but in terms of a suitably discounted value (however rough or arbitrary the rate of discount may be)

in order to ensure that the sheep and goat are not counted at the same face value and there can be a clearer appreciation of the comparative real value of the aid.

The U.S. PL480 food aid, which is an outstanding example of commodity aid, may perhaps deserve a special mention. The relatively low opportunity cost of this aid has certainly made more aid available from the United States than would have been the case otherwise. There may have been some misuse of this aid in some cases in the earlier years. But it must be said to the credit of the United States that she has made serious efforts to ensure that this operation did not degenerate into dumping, causing undue disruption to the commercial sales of other exporting countries or inhibiting the growth of agriculture in recipient countries. I am not sufficiently familiar with the experience in other countries, but it is my considered opinion, in spite of views expressed by some Indian and American economists to the contrary, that over the long period U.S. sales of wheat have not adversely affected wheat production in India. It is not widely known that over the 14 years during which PL480 wheat has been supplied to India, India's own wheat production has gone up from 7 to 22 million tons; and even during the period before the new high-yielding varieties were introduced, wheat output had gone up to 12 million tons. This was the result of the fact that the Indian as well as American authorities concerned tried their best to ensure from the beginning that the imported wheat was not sold in India at terms that might discourage domestic production.

As regards the pattern of aid, there has recently been considerable public discussion about tied and untied aid and program and project aid. The tying of aid can be either to a country or to a purpose. Tying of aid to a country has often led to a substantial erosion of its real value, because the recipient is prevented from buying from the cheapest market. There is therefore a very strong case for untying all aid. Whatever might have been the arguments from the standpoint of donor countries in favor of tied aid in the past, they have lost much of their validity now when there is a fairly large number of donor countries, the industries of each having a possibility of competing for the goods to be purchased by the developing countries with aid received from other donor countries. What some may lose in the swings in a particular year are likely to be made up in the rounds over a period of years.

For aid tied to a purpose no general conclusion is possible. For certain countries and for certain purposes, aid-tying of this kind may have considerable justification. But as a general principle, for a developing country that has demonstrated its capacity to use the bulk of its aid efficiently and economically it is better to have minimum recourse to tied aid. To the extent that the tying clause inhibits the initiative and flexibility of the aid-user it may have certain counterproductive consequences.

Aid tied to a purpose can take the form of program aid or project aid.[1] For countries with a reasonably good overall program or plan for national development, which have given good evidence of capability for constructing and managing projects and/or have already developed the capability of manufacturing a significant proportion of the components required for a project, it is generally better to provide program aid, not merely on the ground of efficiency and flexibility but also for the added benefit that it helps to develop local capability and makes better use of the productive capacity that has already been developed. After all, the objective of development aid should not merely be the creation of physical assets but also the development of technical and managerial capability of the local people. Program aid, if well planned, can provide this much better than project aid. For countries that do not fulfill the criteria mentioned, project aid may be not only unavoidable but desirable; but even then it may be better to have a combination of program and project aid rather than pure project aid. Further, provision for on-the-job training of the local people and progressive relaxation of restrictive clauses should be regarded as an important element of every project. If in exceptional cases certain controls seem unavoidable, care should be taken to ensure that these are considered as no more than temporary crutches to be removed at the earliest possible opportunity.

Channels of Aid

As for channels for providing aid, it is best done through international, regional, or national development institutions or banks which enjoy considerable autonomy and flexibility to deal appropriately with the widely differing situations

[1] Program aid is formulated in the context of the recipient country's overall development program or plan, a direct objective being to provide imports needed to increase production or to extend productive capacity. The direct objective of project aid is to finance part or all of a single tangible investment.

obtaining in different areas of developing countries at different stages of development and which have sufficient continuity and perspective to build up over time a fund of expertise and detailed information essential for guiding economic and social development in such widely different situations and along lines that give reasonable promise of success. The World Bank group and the Inter-American, Asian, and African Banks are typical examples of such international and regional institutions. The two U.S. organizations, I.D.C. and I.D.I., proposed by President Nixon for channeling development assistance, will be similar institutions developed on national lines.

These proposals certainly represent a considerable improvement over the present system obtaining in this country, and his proposal for completely separating development assistance from security assistance is also most appropriate. Care must be taken, however, that the proposed aid institutions do not expand beyond a manageable size and that their bureaucratic and technocratic complexities do not proliferate on such Parkinsonian lines as to become inefficient, dilatory, and counterproductive in the long run. When the volume or variety of work develops beyond a certain magnitude it is better to start a new institution than to add and expand departments in the old. I think bureaucrats often tend to claim too much for economies of large-scale operations. Medium-sized organizations, working in some healthy rivalry with each other, are usually a better guarantee for efficiency, flexibility, and initiative than a number of departments leading almost an "existential" life, frustrated with one another, within a giant monolithic organization.

For the smaller developed countries, national aid agencies may be unduly expensive and the best thing for them may be to operate only through international agencies like the World Bank or the regional banks. But it is obvious that for the bigger developed countries like the United States a national aid agency may be not only economic but also useful in various ways. But wherever delicate international susceptibilities are involved it would be useful even for a big donor country to utilize international agencies. Developing countries may be poor but they are not without pride. They will often accept unpalatable advice more readily from an international rather than a national aid agency, especially if the latter belongs to a developed country which in their view has certain special axes to grind. An international organization can also mobilize the needed expertise from different countries with different outlook and experience and use it more efficiently in the aided countries than a national organization can often do. While there is need and scope for both international and national aid organizations it would be a definite advantage if some preference is given to the former whenever there is a question of conflict.

Focus for Aid

In the context of aid policies, attention has generally been concentrated on the widening gap between rich and poor countries. But the question of the growing gap between the rich and poor communities or regions within developing countries also deserves the urgent attention of all who have a serious concern for the process of economic development and the focus for aid.

It is important to recognize that most measures for economic development represent essentially a "pull from above." Those who happen to be in a "higher" or relatively privileged (or advantageous) position (in respect of capital, education, business contacts, etc.) benefit first from this pull, and the gap between this and the "lower" or underprivileged groups tends to increase. It is through a subsequent process of "diffusion" that the benefits may get passed on to lower groups and the gap may become narrower.

In a developed economy, which by its very nature is more homogeneous and dynamic and has greater horizontal as well as vertical mobility of labor, better facilities for education and communication, and stronger countervailing powers exercised by labor and by government, the process of diffusion is quicker. In an underdeveloped economy, which by its very nature is more heterogeneous and static and is deficient in these characteristics, the process of diffusion is not only much slower but sometimes may increase the gap between the higher and lower groups so much that bridging of the gap becomes almost impossible and some of the latter tend to become enclaves of backwardness and continue to be unaffected by the diffusion process even over a long period. The so-called "dualism" then manifests itself in an extreme form.

This has happened in agriculture. The green revolution has benefited mainly irrigated areas and has tended to increase disparities. In industry technological changes have generally tended to favor big industries over small industries; most of the innovations have been capital intensive and favorable to large-scale operations. The fact that money rate of wages has tended to be higher than the shadow rate of wages while the

money rate for capital goods, especially if obtained through aid or an overvalued foreign exchange rate, has tended to be lower than the shadow rate has accentuated this tendency.

This process, if unchecked, will soon create an explosive situation and in the long run go even so far as to divide people into two different species as it were, namely, those who could get a hold on the "ladder of economic progress" and those who missed it.

The corrective measures may be:

(a) Providing on a large enough scale special socioeconomic measures (e.g., child nutrition, medical aid and family planning, education, apprenticeship facilities and scholarships, social and geographical mobility, rural electrification, easy credit facilities, agrarian reforms, etc.) that will provide a "push from below" to the underprivileged groups to supplement the pull from above which most economic development measures usually represent.

(b) Concentrating international aid on special terms to the backward areas and underprivileged communities in developing countries so that the pull from above represented by technological innovations and other economic development measures may have a relatively greater and more direct impact on them and may provide them with a reasonable hold on the ladder of economic progress.

(c) Encouraging procedures and techniques that would especially favor backward areas and less privileged groups and provide them with a number of auxiliary ladders to help them get on to the main ladder of progress.

(d) Supplementing commodity-and-technique-based research with area-based research, adapting the results of the former to the specific needs of backward areas and groups and emphasizing research that would favor the latter.

(e) Adopting measures to reverse the present distorted relationship of money and shadow prices of capital and labor.

(f) Inducing big entrepreneurs to promote subsidiary or satellite enterprises that would favor backward areas or underprivileged groups.

While the direct benefit of such measures will be felt by the underprivileged groups, there will be also a healthful effect on other groups without widening social disparity.

Why Aid?

I have tried to answer in my limited way all the questions that were put to me by the president of this conference: whither aid, what amount, what types, and what channels? In conclusion, I should perhaps also answer a basic question that he did not put to me, perhaps considering it to be self-evident. "Why aid?" Because this question has often been answered in this country from narrow and transient standpoints, e.g., containing communism, aiding allies, disposing of surplus, and so on and so forth, aid has come to be criticized and misunderstood often in both donor and recipient countries.

The answer that aid has to be given in the enlightened self-interest of both the donors and recipients is certainly better than the above reasons. This point has been so well explained by the Pearson commission [2] as well as the Peterson task force [7] that it is unnecessary for me to go over the ground again. Apart from various general benefits noted by them I may draw attention to a direct economic benefit illustrated by Table 3, which indicates how much bigger a market the developing countries could provide for the goods and services of developed countries if they got the aid and achieved the rate of growth envisaged for the Second U.N. Development Decade. The additional employment and income that this bigger market will provide needs to be brought to the notice of those critics in the developed countries who tend to feel that the aid and trade policies envisaged by the United Nations would not benefit the working classes of their own countries.

But I feel that this purely rational approach needs to be leavened by a trace of another, not so rational, approach that a very long time back a great son of the East, Buddha, chose for himself in one of his earlier incarnations. It is said that at the end of a very long period of meditation and penance he was granted by God the boon that he was striving for, namely, eternal salvation for himself. But just when he was about to achieve his cherished goal he looked back and saw the misery of the people he was leaving behind in the world. He then immediately turned back. He said that he would not be true to himself if he secured salvation for himself alone when millions of his fellowmen continued in misery.

Those of us who individually or as members of a fortunately placed group have been able to enjoy many of the better things that the world can provide, should perhaps, like Buddha, approach the problem of aid not merely in the spirit of what self-interest, enlightened or other, will be served by it but by what we owe to our own spirit, not by way of charity but by way of service.

This last observation, I am afraid, may not be economics. But it is certainly along the same spirit that prompted Alfred Marshall, a great son of the West, to keep the statue of an emaciated man on his table when he toiled over the difficult problems of the social science, the development of which he made the mission of his life and which is also the avowed objective of this Association.

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Discussion: JOHN L. FISHER, University of Arizona

Food and fiber problems recognize no race, creed, color, or national origin. It is time for the agricultural disciplines to shake off their traditional national orientations and become fully internationalized. This meeting's heavy emphasis on worldwide aid, trade, and development is commendable.

The lack of political will being viewed as the cause of a declining quantity of aid from the United States, while aid from the other developed countries is increasing in both quantity and quality, is well taken; however, it is a symptom rather than a cause. Political leaders' lack of will is a reflection of the lack of public will. The "aid story" must be told more objectively and accurately and distributed to a much wider audience.

In the current worldwide economic/political environment the opportunity to influence the course of history for the better lies more with effective aid programs than diplomacy or military strength. The war-torn areas are tired of war, and aid will soon be exerting more influence than ever before. The United States is cutting back at precisely the wrong time. The "Tragedy of the Agency for International Development (AID)," more than "Vietnam," may be classed by historians as the "tragedy of our time."

The shift in U.S. aid from grants to loans is of questionable wisdom, and a redefining of the term aid is in order. We gave Europe and Japan much more to rebuild than we are giving to the Third World for development. We gave to the "down-and-out rich," but we are loaning to the bonafide poor! A review of who gets aid reveals that aid follows donor national security and vested business interests very closely.

Aid, trade, and foreign investment should be viewed as a troika. Buying an LDC's product is the best aid a developed country can offer; but enlightened foreign investment has equal potential for increasing productivity, thus can foster economic development. Utilizing enlightened foreign investment as an aid tool has received inadequate attention. *Enlightened* is the key word. The private sector is the major source of the United States' economic strength, and more effective ways for involving it in the aid effort are needed.

AID has been seriously hampered in its effectiveness by being used as a tool to support security and military objectives. Administrative limitations and harrassment from vested interests have taken their toll too. It is difficult to "localize" aid-initiated activities, and freedom to be flexible in modus operandi is required. The maze of regulations and red tape must be reduced.

Program aid is better, but it can be used only when the host country has (a) a sound strategy for development and (b) institutions capable of implementing the strategy. Unfortunately, few LDC's have an adequate strategy, and neither the agricultural professions nor the aid agencies are being of much help.

The following need immediate attention:

(1) A thorough worldwide study of aid to ag riculture.

(2) Problems that will be created by channel

ing more U.S. aid through international organizations.

(3) Administrative weaknesses in agricultural ministries and agencies.

(4) Maintaining a balanced program and an "action orientation" in AID.

(5) Fostering the formulation of sounder national strategies for development.

(6) A fitting "philosophy of aid?"

(7) Aid agencies' overbureaucratizing.

(8) Getting and holding competent manpower in the aid agencies.

Discussion: RALPH K. DAVIDSON, The Rockefeller Foundation

We have before us two papers dealing with "Policy Issues in International Trade and Economic Development." The less developed countries have two-thirds of approximately 3.6 billion people but receive only 12.5 percent of the world's gross national product. Dr. Sen points out that the number of able-bodied workers in developing or poor countries is likely to increase from 662 million in 1970 to 829 million by 1980, an increase of 25 percent. Unemployment is substantial and rising. These largely agricultural countries will have to absorb the workers, if they are to be employed, primarily in nonindustrial employment. As Dr. Sen tells us, considerable misery and social unrest (with serious potential for trouble for the rest of the world) can be avoided only with prospects for suitable employment and a reasonable increase in per capita real income, which is today unduly low. What are the prospects?

Many developing countries have tried the path of economic nationalism and found it wanting. There is growing recognition that high-tariff, quantitative-control, import-substitution policies have impeded the internal structural change required for sustained growth and development and have aggravated problems of unemployment and underemployment because of overpriced labor and subsidized capital. In an important sense the fundamental issue for the future is the conflict between political forces of nationalism and economic forces pressing for world economic integration.

Current positions are not bright. In agricultural production where the United States has a comparative advantage domestic farm policy has facilitated exports; but in lines of production where imports are competitive the United States has turned to quantitative restrictions that are unduly harmful to poor countries.

Simultaneously U.S. official aid to the LDC's is falling, with little prospect of reversing the trend. One must agree with Dr. Sen that "the basic reason is the lack of political will among U.S. authorities." Decline in net aid also has intensified debt-servicing problems for the LDC's, who can make repayments only by expanding export earnings sufficiently. What are the prospects? The U.S. and other developed countries have used tariffs and quantitative restrictions, voluntary and involuntary, to keep out or reduce manufactured imports from the LDC's, generally of a labor-intensive variety. In a period of inflation and government concern with rapidly rising prices, the government has not fully utilized imports as a restraint on rising prices and costs. They could be an effective anti-inflationary pressure.

Prospective expansion of the EEC with its Common Agricultural Policy raises severe questions for U.S. agricultural exporters as well as those in the LDC's. Houthakker reminds us that the United States is not likely to make much progress in getting other countries to reduce restrictions unless we reduce our own. How likely is that?

The United States is moving to a service economy with a smaller proportion of its labor force in goods-producing industries, substantially more in the service areas and slightly less in agriculture. Workers in goods-producing industries are facing increasing foreign competition and turning to protection. The service areas, through management contracts and multinational firms, are more export oriented. General consumers of course gain from importing lower-cost goods. The United States has been the leader and originator of every major initiative in world trade policy since 1934, but I rather doubt that present national leadership will have the political will to carry the case for expanded trade and greater aid for poor countries. Unless the United States or an expanded EEC responds to the issues in terms of enlightened self-interest and service the world problem of growing unemployment and a widening gap between rich and poor will become worse.

INSTITUTIONAL REFORM: IMPLICATIONS FOR AGRICULTURAL ECONOMICS

CHAIRMAN: HAROLD F. BREIMYER, UNIVERSITY OF MISSOURI

Institutional Reform: Implications for Agricultural Economics*

EMERY N. CASTLE

In a book originally published in 1961 and credited by many as one of the most prophetic of recent interpretations of American history [15], William A. Williams took as his thesis the proposition that communities are based on love, power, or some combination of the two. Williams argues that there are two kinds of communities. One is described as a benevolent despotism; the other, somewhat less precisely, as democratic and equitable. The latter places love before power and participation before passivity; equity and equality come before ease and efficiency. In a benevolent despotism the many have a passivity concerning power and in return accord the few who enjoy power a defined relationship of love and affection. Williams argues that benevolent despotisms have difficulties sustaining themselves. He has concluded from his study of recent American history that our present polarization can be ascribed to a conflict between those who wish to retain a benevolent despotism and those who wish to change to a more democratic and equitable society.

While this description is useful, a more sophisticated formulation is necessary for the purposes of this session. The impact of technological change on the distribution of the effects of group decisions, the scope provided for managerial skills, the impact on group persuasion and information assembly are of great importance and must be accounted for in a systematic fashion.[1] To be more explicit:

1. Specialization has increasingly created interdependence. The nature of our interdependence has changed, largely because of new technology, and new groupings and new ways of making group decisions have emerged or pressure for such change has been manifested [12, 1].

2. Technology constitutes one of the tools of political power and has made possible its increased concentration. In other words, for one who has the talent and the inclination, skilled use of technology has greatly increased the "size of firm" for those who have the capacity to acquire, hold, and exercise power.

3. One important limitation to size of firm in this context is nonlinearity of important attributes of group activity. A feeling of individual identity and meaningful participation are examples of significant variables that may not vary in a linear way as size is increased.

4. That which we expect of the public sector in the production of public goods cannot always be standardized and routinized. The feasible size of unit for persuasion, for mass dissemination of information, or for the provision of a standardized public ultility may be very different from the feasible size of unit for the production of education, health, and governmental services generally. If important attributes of public goods are long ignored in their production, these neglected attributes will eventually become so obvious as to force reorganization, cause the public goods to be redefined, or serve as a brake to size of operation. The application of cost effectiveness analysis to the production of public goods is often undertaken without recognition of why the public sector was turned to in the first place. In some

* Oregon Agricultural Experiment Station Technical Paper 3185. This paper has benefited from the insights and suggestions of my reactors at the 1971 annual meeting and in particular from the comments of James Bonnen, Mark Buchanan, and Harold Breimyer. Their kindness in suggesting and permitting these changes in the published version is much appreciated.

[1] We have reference here to power in a political sense. To the literal-minded economist power may represent an intangible concept incapable of measurement or precise definition. There is considerable evidence, however, that the way decisions are made cannot be divorced in many circumstances from their effect or content. If this is so, and as the public and private sectors become increasingly intermingled in economic activity, it becomes apparent the economist will have to make his peace with political scientists and that he will need to understand better political events and political trends. For those who wish to pursue the subject of power, the recent work of Adolf A. Berle is recommended [2].

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instances this was because the public good could not be defined in the homogeneous terms necessary for operation of the market place. Such moves as government reorganization and revenue sharing are manifestations of attempts to accommodate these externalities and lack of homogeneity in the production of public goods.

The Problem

In his letters asking for this paper on "Institutional Reform: Implications for Agricultural Economics," President Hillman said, "In order to come to grips with the problems of our profession and Association we must try to assess what is happening in a broader context in history and to address what can be done about it. How do we get institutional reform and how will it affect us? It is this topic which I hope you will develop and to which I hope your reactors will speak."

In recent years an increasing number of our profession have become aware of the importance of the economics of institutions, although a significant number in the profession have always been aware of the subject. But significant progress in the development of the positive economics of institutions has not been observed. As a consequence, those of the profession who engage in policy formation and actual institution-building are very much engaging in an art; the knowledge they gain in the process is usually interred with their bones. Yet as one observes the impact of this profession on the policy process generally, the hypothesis that economics has much to do with institutions and their formation is a reasonable one.[2]

[2] This session is explicit recognition of acceptance of the notion that institutions should be considered as endogenous rather than exogenous variables. Two years ago at the Association meetings, James Shaffer gave a major paper on institutional obsolescence [14] and reactions from the profession were invited and were later published. In one of the contributions James Youde and I called attention to numerous reasons why progress has been slow in creating reliable knowledge on institutional change [9]. In that article we noted that in 1952, approximately twenty years ago, S. V. Ciriacy-Wantrup called attention to the importance of treating institutions as variables rather than as constraints [10]. In 1965 I argued that the major focus for land and resource economics should be on the economics of institutions and public goods [6]. These portions of Ruttan's presidential address on institutions and Johnson's lecture on public goods reported in these proceedings serve to legitimize Wantrup's earlier writings on these subjects. In this paper I have resisted the temptation to explore this subject in greater depth because I believe it was Hillman's hope that more pragmatic and pressing problems would be treated.

Specifically, Hillman is concerned about (1) the fragmentation occurring in the profession, (2) our alliance with a rapidly eroding clientele base, and (3) the decision process involved in cooperative federal-state research and extension. And if that is not enough, he is also worried about governmental reorganization and reevnue sharing.

In the material that follows, some concepts from political science as well as those of economics are utilized. If the historian Williams correctly identifies the tensions in our society, it will surely be people such as Robert A. Dahl, political scientist, and Mancur Olson, economist, who will provide the stuff by which these tensions will be channeled and related. In a remarkable little book entitled *After the Revolution?* [11] Dahl applies most of what mankind has learned about governance, participation, and democracy to contemporary problems of our society. On reading Dahl one appreciates the ambiguity inherent in the term democracy. The book lends support to a conclusion, already reached and implicit in much of what follows, that the business of universities is education, research, and service. Democracy and participation are relevant to the extent that they affect motivation in the accomplishment of these ends. They are not ends in themselves.[3] But of course this is not to say that an educational institution in an authoritarian society would or should be identical with one in a society where participation is widely disseminated. It is argued later that the strongest educational system for this nation is one with considerable flexibility and numerous access points that will permit it to consider social problems arising at different levels of aggregation.

Contemporary Issues and the Profession

Focus is now shifted to those institutions under fire that are of the greatest importance to this profession. The approach will be pragmatic

[3] In part because I have discussed the issues elsewhere [8] and in part because I believe there are more fundamental forces involved I resist the temptation in the next section of the paper to address possible conflicts of authority and academic freedom in the conduct of mission-oriented research. Academic freedom is a derived freedom; it is granted by society to the academic person because it is believed it will serve the social good. It is obvious that those who control the purse strings can control the academic operation, given time and perserverance. Therefore, the administrators must be assumed to be in charge of our research establishment at any given point in time. The issue is not whether they have the authority; the issue is how they use it.

and somewhat ad hoc in nature. However, there has been considerable reliance on two earlier papers which establish much of the groundwork for that which follows [7, 8]. In the interests of conserving space these arguments are not presented here.

The central institution selected for analysis is the USDA/land-grant university partnership in education, research, and teaching. No attempt will be made here to explain this system in total. It is recognized that it does vary from state to state and that there are many subsystems within the total institution. Specifically there are research, extension, and resident instruction components. Although these are often treated separately in the material which follows, it should be recognized that it would be difficult to change one part without changing the total system.

The principal reasons for selecting the USDA/land-grant relationship for special emphasis are:

1. Most of us are products of this system to a greater extent than we realize.

2. Our current activities are influenced greatly by the structure of this system.

3. If federal reorganization and revenue sharing (as envisioned by the Nixon Administration) were to become fact, the impact on our profession would indeed be substantial; both the research and the extension framework would be significantly changed.

The problems associated with this system have been discussed extensively within the system itself. Some of this discussion has found its way into print; writings by Bonnen [3] and Shaffer [14] provide examples. The system is frequently criticized on the grounds there is (1) fragmentation, (2) duplication, and (3) failure to take advantage of the economies of scale. The cause of this state of affairs is usually attributed to (1) lack of centralized authority, (2) parochial state interests, and (3) the inflexibility of universities.

Several statements are now offered to summarize what are believed to be relevant considerations associated with the federal-state cooperative program:

1. A recurring research fund base provides a substantial advantage when university departments prospect for other sources of funds. Much variation exists among universities and among departments within universities as to how this advantage is used.

2. The bureaucracy associated with the program is vast and highly complex. This is in part a function of the broad dispersion of power that exists.

3. The process of conceiving, initiating, and administering research projects is often slow and cumbersome. This is particularly true of regional research. Often the most able people in the system attempt to escape involvement because it is extremely expensive in terms of time and talent. The existence of social problems other than "agricultural" and the availability of funds for work on such problems has made escape from the system possible for those who wish to exercise their entrepreneurship.

4. Departments within the schools and colleges of agriculture are very much multiple-product firms. There is a tendency for them, as well as their school or college and their experiment station, to hold both inputs and outputs in rather fixed proportion over time unless subjected to severe outside pressure. Furthermore, their choice indicators are always different from those of their USDA counterparts. There are at least two reasons for this: (1) The geographic area of responsibility is different, and the political process for defining social problems and priorities is different for state than for national units. For this reason a summation of state problems will not yield the same national problems as when defined by the federal establishment. (2) Concern for a different combination of products exists for the university than for the USDA.

5. One of the principal products of economic research has been the learning it has provided for those participating. While one may fail to produce impressive literature by working on an important economic problem, one can hardly fail to learn a great deal about the problem and about economic research methodology from serious and intensive research. The result is a cadre of people in the universities who can move to government work, often with considerable knowledge of the problems with which they must grapple in government.

These characteristics of the system converge to pose critical choices for both the administrators and the scientists operating within it. In the main the choices faced are not the result of mismanagement or inept individual performance. In coming to grips with the problem there should be recognition of the special needs and characteristics of each participant. I am not an authority on the USDA; our chairman has written on this subject quite authoritatively [4]. However, as far as the universities are concerned, all partici-

pants should recognize that they have other business in addition to cooperative research. This other business requires a type of talent, an orientation, and an approach that are very different from those required for successful mission-oriented, large-scale, tightly organized, cooperative research on problems that are regional or national in scope. Of course, universities, in common with most organizations, do respond with considerable speed to financial incentives. If the sole objective is to get a particular kind of performance from the universities, we know how to do it.

The effect on motivation of worker participation in problem identification and priority setting should not be ignored. Our scholarly tradition conditions us to be critical of ideas independent of source. The psychological obstacle created by having "others" determine "your" research task is not insignificant. Every mission-oriented research organization must face this problem, but the magnitude of the problem surely must be positively related to the size of the organization. With respect to motivation, a combination of an exciting intellectual approach and a burning social issue is far more likely to command the intellectual resources of young and energetic professionals than is a poorly written project statement or task force report that is yielded by the system.[4]

If Nixon's reorganization were to become fact the funds that now go to the agricultural experiment stations would no longer be administered by a Department of Agriculture. This would automatically shift the focus from a relatively better defined subject matter area or clientele base to a relatively less well defined problem focus. Given the direction of development of the schools and colleges of agriculture, one would expect them to adapt to and focus on different problems quite readily. The disciplinary case for their existence has never been strong; their historic justification has been their mission orientation. Currently their strength is organizational and derives from their systematic approach in bringing intellectual resources to bear on social problems. Despite the pressure they have felt in recent years, their record of maintaining and enhancing support is testimony to the political skill of their leadership, as well as to their agility in applying an approach that has been developed over many decades of close involvement with local citizens. Even though they possess these strengths, my own judgment is that they would be significantly weakened if they were to lose their federal sponsor of the same name.

These trends are related to the fragmentation Hillman has observed in our profession. The problems on which we are now working are yielding new subspecializations within our profession. Not all of the people comprising a subfield are to be found within agricultural economics. When this is combined with increased size of our Association and the fact that we are never quite sure whether some of this work is really agricultural economics, the formation of smaller, more homogeneous groups probably is inevitable. It is a credit to our profession that we are using the perspective, viewpoint, and depth of those who are working in related areas. This becomes increasingly important as we turn to new and different social problems.[5]

It is not clear that formation of these subgroups is a matter that should be of great concern to this profession or, at least, to this Association. It is my hypothesis that our people turn to other groups generally for things that they do not expect to find nor are they likely to find in this Association. This does not necessarily imply a weakness of this Association; it may simply mean that our function is largely noncompetitive.

This leads rather logically to the issue of revenue sharing and cooperative extension. The principal philosophic argument advanced by the Nixon Administration in favor of revenue shar-

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[4] This may, in part, explain an interesting phenomenon that can be observed in many universities. Universities generally carefully protect the rights of various participants. They specify the rights and privileges of the participants, and power within the university tends to be widely distributed. Yet within universities one often observes individual project leaders, usually those who have been successful in attracting outside grant funds, exerting virtually dictatorial power over a substantial group of people. Perhaps the extraordinary attraction of the really powerful concept combined with administrative and leadership ability is sufficient to explain this incongruous concentration of power. One is reminded of Berle's laws of power, including the law that power is inevitably personal.

[5] In recent years we have witnessed a broadening of the area of focus of this profession. Some will argue this is overdue and that we are responding to social needs and our salvation lies in this direction. Others will say we have simply been opportunistic and have prostituted ourselves. Funding sources have become correspondingly diversified. Are we really a profession of "agricultural" economists? If so, how can the term "agricultural" be defined to even meet approximately the logicians requirement of a good definition?

ing has been the harm caused by the fact that the federal government must treat everybody alike. The lack of homogeneity among regions suggests, it is argued, that problems should be defined locally and that the involvement and participation of people is likely to increase if funds are transferred to the states. The other side of the same coin gives us the main weakness of the plan. As was mentioned earlier, the summation of state problems will not necessarily result in the identification of the same national problems as when they are defined by national institutions. It is doubtful that extension generally would be as conscious of community development, social inequality, poverty, and consumerism as it is now had the individual states had sole responsibility for selecting problems and setting priorities.

The Normative Implications

In this section recommendations are offered with respect to (1) cooperative-state research relations, (2) the Association and fragmentation, and (3) the possible impact of revenue sharing. Value judgments are obviously involved in each recommendation. While the arguments advanced follow logically from the foundation laid, other recommendations could also be deduced from this same foundation. When one adds to this the fact that there are probable disagreements about the foundation, this section should create considerable room for discussion. Prior to moving to recommendations a partial summary is offered in the form of two presuppositions:

1. Americans generally and economists in particular have long recognized that group processes are necessary to the solution of significant social problems. We argued earlier that modern technology has resulted in considerable variation in size of unit with respect to making group decisions and that new groupings and new orientations have become necessary for the solution of many policy issues.

2. Government reorganization and revenue sharing can be viewed as an attempt to redefine problems and to regroup to better address these problems. The concerns that led to their being advanced are basic, and for that reason these proposals, or substitutes, are likely to be around for a good long time even though the prospects for immediate enactment do not appear especially bright.

In the remarks that follow several statements mention or are critical of some undesirable impacts of revenue sharing and federal government reorganization. These statements do not necessarily mean that, on balance, the author believes these are undesirable policies. The frame of reference of this paper, our profession, is too narrow to permit a complete evaluation. To the extent this analysis has validity, it simply means that adjustments may be desirable in the proposals or, where this is not possible or feasible, that the professional impacts will have to be considered, relative to other impacts.

With these presuppositions as background, we turn to each problem area identified above.

Cooperative-state research

1. Competitive grant funding should be increased incrementally, probably through the existing special grants program, but states and individual researchers should continue to participate in the determination of research problems and priorities. The degree of decentralization that we have permits innovation and experimentation, and this is most desirable. Furthermore, some autonomy is needed for the recognition of state and local problems. At the same time a federal input is needed to prevent regional and national research needs from being overlooked. If we opt for such an arrangement we recognize that some duplication and fragmentation will be inevitable. However, we are conscious of this, and steps are being taken to improve planning and coordination. As evidence I cite a recent manuscript by Mark Buchanan [5].

2. Regional economic research as we know it should be abandoned. Alternative arrangements to attack regional problems should be advanced and tried. Individual station grants, regional centers, and consortia of stations are all possibilities. In addition, Dean Peairs Wilson recently offered a most challenging idea for regional research [16]. It is hoped sight will not be lost of this interesting possibility.[6]

[6] The writer of this paper has devoted a significant percentage of his professional career to regional economic research. This has been counter to the advice and examples set by more outstanding economists. After nearly 20 years of involvement I have concluded that the situation is little better, but no worse, than it was when I first became involved. The most able administrators in the system devote a significant amount of time to regional research as administrative advisers and in regional meetings. Some of the best minds in the agricultural profession have attempted to diagnose difficulties and prescribe solutions. I suggest the reason the pattern has persisted is that better results are obtained in fields other than economics. There seems to be a consensus that the principal

3. Education of people is an important product of the system, and the evidence is that it is best accomplished if the processes do not become too standardized.

The Association and fragmentation

The problems (mentioned earlier) stemming from the proclivity of agricultural economists to abandon "traditional" areas need to be sorted out systematically. There are professional association implications and university implications, as well as USDA implications.

1. As far as the Association is concerned the more restrictive our policies, including our journal and award policies, the greater will be the tendency of our membership to seek other types of associations. But the seeking will undoubtedly continue and should continue, because some of the things being sought are not likely to be found within this Association. At the same time, steps may well be taken to make this Association more hospitable to numerous smaller groups now in existence.

2. It is not the prime responsibility of this Association to define a role for the schools and colleges of agriculture. This is a legitimate subject for study and may be of great importance to many of our members in terms of the roles they play in their respective institutions. However, we will be well advised as individuals to address the policy aspects of this issue through other channels.

3. We should recognize that the traditional sources of funding have enhanced our ability to move into certain new areas in the profession. We should also recognize that by doing so we run the risk of possibly hastening the day when those traditional funding sources will decline. Yet this would be a poor reason for this Association to try to define its mission either narrowly or broadly. Rather, our main objective should be to enhance the quest by our membership for an understanding of the economics of the world around us.

Revenue sharing and extension education

It has not yet been demonstrated to my satisfaction that a feeling of participation and control by citizens generally would be increased measurably by transferring to state government that which is currently being done by the federal establishment. Both tend to be regarded by most citizens as remote and inaccessible. In addition, tremendous variations exist among state governments in size, efficiency, and responsiveness. Furthermore, there are educational problems that are uniquely national in character and that do need attention. As mentioned earlier, the summation of state problems and state issues will not necessarily equal a national or regional problem. One would anticipate that problem orientation would vary significantly from state to state. Moreover, organized groups within each state would undoubtedly attempt to capture the extension program.

Of relevance also would be the changed relationship between research and extension. Because the research and extension organizations would be marching to different drums one would expect a significant gap to develop between the two functions. This would be highly undesirable for many reasons. While it is not essential and in some instances may not be desirable that they be organized in an identical fashion, there is considerable evidence that they need one another now and that each will need the other even more in the future. To repeat, we need a federal-state partnership but with flexibility and numerous access points.

In conclusion, the opportunity to present this paper is appreciated. If the paper serves no other purpose it should demonstrate that the matters discussed deserve careful thought and investigation. From this perhaps support for political science, history, sociology, anthropology, and economics being generated by the federal-state research and extension programs will be enhanced. My limited reading in the twilight zone between economics and political science, which has been visited by such people as Robert Dahl, Mancur Olson, James Buchanan, and Gordon Tullock, has convinced me that we have much to learn and gain from such efforts. By such efforts we can hope to provide an answer to the question, "How do we get institutional reform and how will it affect us?"

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value of regional economic research has been professional improvement resulting from regional contact. I am inclined to agree with this, but surely there must be less expensive and frustrating means of accomplishing this end. Currently, there is emphasis on multidisciplinary task forces. If these are continued economists surely should be involved. However, I believe the time has come to evaluate the amount of funds and the manpower involved and judge whether this is a defensible procedure. For a scholarly discussion of regional research, an article by Harris and Hildreth is recommended [13]. While I do not regret the time spent in trying to make regional economic research work, I am now willing to accept the hypotheses advanced earlier by others as to its lack of productivity.

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Discussion: SHERWOOD O. BERG, University of Minnesota

Emery Castle has given us a lucid discussion of the general setting in which any group in our society must make its decision; of the changes in distribution of power that are likely to flow from a continued advance in science and technology; and of contemporary issues, namely, revenue-sharing and federal reorganization, that are likely to result in institutional reform. The last begs the question, "What can be done about it?"

The rationale for institutional change was underscored by Vernon Ruttan in his presidential address when he extended the theory of "induced innovation" to include the process of institutional innovation. Emery Castle also points out the growing awareness of the importance of the "economics of institutions." Even recognizing some of the economic forces at work, the redirection of effort in both the natural and social sciences represents an exceedingly difficult challenge to institutional innovation. Castle suggests that government reorganization and revenue-sharing may be a recognition of the need to "redefine problems and to regroup to better address these problems." However, we are well aware that the public sector has traditionally experienced great difficulty in generating support for research designed to produce social change.

There is another aspect to this general problem in the university setting. As Castle pointed out, the disciplinary case for the existence of agricultural economics has never been strong. Its historic justification has been its mission orientation, and part of its strength has been its organization and systematic approach in bringing intellectual resources to bear on social problems. The university department has served well, allowing for some flexibility and innovation in teaching and research. Moreover, many departments have operated to apply a "reductionist" approach to problems, which has served to advance the science and has effectively prepared future faculty members to carry on the tradition under which they were educated.

But new conditions have arisen. Reductionism is not the only way to advance science; and in terms of public interest the most urgent problems do not fit into departmental boundaries, which may in fact become barriers to the collaboration of scholars whose knowledge and techniques defy traditional compartmentalization. In terms of the University's abilities to improve its own programs to adapt constructively to the financial, political, and other pressures bearing upon it, a strong case can be made that the principal cen-

ters of curricular, research, and planning responsibility should be fewer in number and broader in interest than the department. Perhaps the profession should be laying strategies that would strengthen its position in the years ahead—strategies that will accommodate a variety of subgroups: long-lived and short-lived; pure, applied, or mixed; undisciplinary and multidisciplinary.

Discussion: MARK T. BUCHANAN, Western Regional Agricultural Experiment Stations

If a goal of Hillman and Castle was to stimulate thought they succeeded admirably, at least for this panelist. This outcome was assured by the lack of specificity in both the challenge and the response. I choose to think that this was deliberate.

I shall comment first on philosophy and then on what Castle calls the cooperative federal-state research program (and/or system).

First, philosophy. It is my opinion that the major tension that Castle seeks to identify and apply is self-determination vs. authority. The individual is the basic unit, not the institution. Institutions presumably encompass the values of their participants, for a time at least. Benevolent despotism and democratic and equitable society are merely descriptive phrases pertaining to portions of the continuum of means by which individuals and societies address the primary issue. Power is another such expression.

Expressions of discontent with things as they have been are observable phenomena. One may speculate on their causes. Studies in depth into these matters could yield useful results. I agree with Castle that a feeling of identity and of meaningful participation are values that will continue to be prized by individuals whatever the structure and size of institutions and societies. This is a basic force with which we must continue to deal.

I hypothesize further that as the economy advances, as educational opportunities and participation are still further extended and intensified, and as the technology of information exchange improves even more, questioning will intensify as well. Individuals will question still more than they do now what they have accepted previously out of naiveté, faith, and prior belief. Educational, research, and public service institutions and their programs will be subject to such challenges just as other organizations and ideas will be.

I perceive all this as an opportunity and challenge for us, as individuals and as members of our professions and institutions, to perform the useful function of identifying and illuminating options at critical points in decision-making processes. In so doing many of us may satisfy our need for meaningful participation as well.

This leads to what Emery calls the federal-state research program (or system) as one of the elements with which we deal. With respect to this system, I propose the following:

1. Study the primary system comprised of 53 state agricultural experiment stations and 7 USDA agencies in depth. Identify and describe similarities and differences among and within these primary components. Trace relationships with other state and federal agencies. Identify teaching, extension, and industry linkages.
2. Identify critical decision points for each component of the system: Department Chairman, Director, Dean, Dean of Graduate School, Vice-President, President, President of Board or whatever, State Budget Director, Governor, Chairman Appropriations Committee, et al.
3. Identify and illuminate the options available at each critical point.
4. Deliver and explain the information to the right person at the right time and place; otherwise it will be only an academic exercise.
5. Focus on societal needs as well as on the needs of our profession: "Ask not what your country can do for you but what you can do for your country."
6. Participate in information exchange, priority setting, and other joint planning activities with other segments of the system.
7. Change the reward system as necessary to make these kinds of studies attractive to competent people, some of whom should be in Department; others would be staff for administrative officers.
8. Recommend the institutional and organizational changes needed to make the system work better.

INTERNATIONAL AGRICULTURE

Program Organizer: Lyle Schertz, Foreign Economic Development Service, USDA

International Agricultural Adjustments, 1970–1980*

Oris V. Wells

I was most hesitant about accepting the invitation to prepare this paper. For over ten years now I have been basically an administrator rather than an analyst. I serve as an executive officer of the FAO (Food and Agriculture Organization of the United Nations), and very frankly this paper must chiefly be a statement of the pressures or main problems with which I believe all of us concerned with agricultural development, whether working in national or international agencies, will be faced during the several years immediately ahead. It is also a fact that I much prefer to prepare papers after the chance of an oral presentation and full discussion, rather than several months in advance. But I of course understand the reasons why papers for certain sessions of the Association should be prepared and circulated ahead of time, and I am also aware that the terminology "developing" and "developed" countries used in this paper is not as scientific as some might desire. Nevertheless the terms are convenient and I believe generally well understood. I reserve for myself the right to amend such ideas as are here presented, if this seems desirable, when the actual discussion occurs.

I

We should start, I assume, by asking what is meant by "adjustments in agriculture" or, more simply, "agricultural adjustment." So far as I know, agricultural adjustment, at least in the sense in which I shall use it, developed some time during the 1920's. Looking some fifty years back to the January 1921 *Journal of Farm Economics*, I find the lead article was in fact one of the major papers at the December 1919 annual meeting of this Association, given under the title "The Adjustment of the Farm Business to Declining Price Levels" by the man who was generally regarded as the ablest agricultural economist of the time, Dr. Henry C. Taylor.

Taylor addressed himself to the then prevailing situation, which most farm people "thought was discouraging and in some instances disastrous." In short, World War I had caused a substantial inflation in commodity prices, including farm commodity prices; and the sharp drop which was then in process—a drop which was to reduce American farm prices within a twelve-month period by something more than 50 percent—seems to have been looked upon by Dr. Taylor as inevitable or, as he more mildly put it, "not without precedent."

His title you will note was not agricultural adjustment but rather "the adjustment of the farm business"; and he spent most of his time suggesting that farmers curtail their farm expenses in every feasible way, calling attention to the need for cutting farm power costs by continuing the use of horses and horse feed, by endeavouring to reduce farm wages and cash rents, by increasing production for use by the farm family itself, by returning to simpler forms of social and community life, and by giving increased attention to cooperative endeavors. Dr. Taylor could not resist, however, some three or four closing paragraphs in which he pointed out that such retrenchment on the part of the farmers would not save many of them, that its effect on the overall economy would not be a desirable one, and that in the near future either the international situation had to right itself or the American farmers would in fact be asking their government for some kind of remedial action. Dr. Taylor's concluding remarks were of course soon well justified by the arrival of the Wallaces (H. C. and H. A.) in Washington, by the rise of the Farm Bloc in the U. S. Congress, and by the McNary-Haugen Proposal. So it was no surprise to find that John D. Black, then at the University of Minnesota, was writing for the *Journal of Farm Eco-*

* I am indebted to a number of my colleagues in the FAO and elsewhere for advice or assistance in developing this paper. The responsibility for ideas expressed here, however, are wholly mine and they do not necessarily represent the official policy of FAO.

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nomics in April 1925 about "The Rôle of Public Agencies in the Internal Readjustments of the Farm."

Without going further I suggest that we consider "adjustments in agriculture" and "agricultural adjustment" as more or less interchangeable and as referring to those agricultural adjustments which national governments and international agencies endeavor to encourage or assist farmers to adopt or which they themselves endeavor to put into action either through national or international arrangements. In short, my central interest in the problems of international agricultural adjustment during the decade ahead does not assume any particular pattern of change as inevitable but rather assumes that public agencies, whether national or international, are and must be concerned with assisting in or bringing about those changes that the international community agrees are most desirable (and I am of course also interested in the means by which such agreement may be reached).

II

This brings us to the question of the shape of the modern world. What are the prospects and problems of agriculture, especially at the international level?

As for the current situation, the preliminary statistics now available indicate that for the third successive year world agricultural output was characterized in 1970 by a continued modest increase in the developing countries and a stable level of output in the developed countries—chiefly due on the one hand to the recovery from drought and spread of high-yielding wheat and rice varieties in the Far East and on the other hand to the restriction of acreages and the maize blight in North America. That is, total world agricultural output was up perhaps 2 percent in 1970 compared with 1969, with per capita output about constant; while carryover stocks of wheat, coarse grains, and dairy products in 1971 are down, rice stocks are up. In short, the world's food and agricultural problems are still far from being solved, with per capita production in the developing economies averaging, so far as I can tell, about the same at the end of the 1960's as at the beginning (1960-1962 versus 1968-1970).

Meanwhile, within the last three years the system within which I work has produced at least two main documents and a recent proposal that should be briefly noted. The first of these is the FAO's preliminary Indicative World Plan for Agricultural Development released in August 1969. This Plan indicates the main challenge of the future is to provide the food for the developing countries whose populations are now growing at the rate of 2.5-3 percent a year, while also calling attention to the fact that most developing countries will continue to depend mainly on agricultural exports for earning much needed foreign exchange. The Plan then raises the question of international trade policy and of how far agriculture will be able to absorb an additional four hundred million people, which is the forecast of the probable increase in the rural population between 1962 and 1985. The Plan suggests that cereal production must lead the way in solving food supply problems in the most overpopulated parts of the world; but nevertheless the problems of protein supplies are particularly important, especially for pregnant women, babies, and small children. This preliminary Plan has been discussed in detail by the FAO's Governing Council and Conference, and the Director-General has now been instructed to continue studies in this field under the name of a "Perspective World Plan of Agricultural Development."

More recently, as of November 1970, the United Nations General Assembly has adopted a policy statement or comprehensive set of targets for Development Decade II. This statement calls for "an average annual growth of at least 6 percent in the gross national product of developing countries during the decade 1970-1980, including an annual average expansion of (a) 4 percent in agricultural output and (b) 8 percent in manufacturing output."

This same statement goes on to indicate that "as the ultimate purpose of development is to provide increasing opportunities to all people for a better life, it is essential to bring about a more equitable distribution of income and wealth for promoting both social justice and efficiency of production; to raise substantially the level of employment; to achieve a greater degree of income security; to expand and improve facilities for education, health, nutrition, housing, and social welfare; and to safeguard the environment. Thus, qualitative and structural changes in the society must go hand in hand with rapid economic growth, and existing disparities—regional, sectoral and social—should be substantially reduced." This document, of course, contains a long section on trade, calling for arrangements that will generally tend to stabilize commodity prices and income, eliminate or reduce tariff bar-

riers, and more especially allow increased export markets for the developing nations of the world.

Clearly this strategy for the Second Development Decade gives as much attention to social objectives and human development as it does to economic objectives. The section that was perhaps most difficult to agree upon has to do with the recommendation that each economically advanced country should endeavor to provide by 1970 annually to developing countries resource transfers "of a minimum net amount of 1 percent of its gross national product," with the special proviso that those developing countries unable to achieve this target by 1972 will endeavor to attain it by not later than 1975. At the same time, the UN statement recognizes that "developing countries must, and do, bear the main responsibility for financing their development."

The most recent statement, to which I call your attention and which I think also underlines the importance of the discussion of international agricultural problems by this Association, is the address by Dr. A. H. Boerma (Director-General of the FAO) to the International Federation of Agricultural Producers on the occasion of its 25th anniversary session in Paris, May 14, 1971. The Director-General of FAO called attention to the fact that for 25 years the FAO and the IFAP have been pursuing a common interest, that is, endeavoring to provide more and better food for people throughout the world and seeing that those who produce it are adequately rewarded for their efforts. The Director-General is not too pleased with the results to date: "For what do we (now) have?" he asked.

In answer he called attention to the "vast regions where neither the land nor the waters of the world are properly cultivated," where the majority of mankind is in one way or another badly fed, and where the countryside is inhabited by millions of people living in extreme poverty, while on the other hand there is another, smaller part of the world where it seems too much food is being produced and where governments are either paying farmers to cultivate less land or dispensing large sums of money to support farm prices. He calls attention to the trade figures of the world, to the need for more rather than fewer rural jobs over the years ahead, to the continuing importance of food aid in many areas; and he asks, "What can then be done to change the generally unfavorable pattern of world agriculture?"

To start with he feels there must be a complete change in the attitude towards the agricultural sector, recognizing that the developed world as a whole must provide additional aid for the developing countries, not only directly but also by revising some of their production and trade policies. For the developing countries themselves there are a whole series of policies they need to pursue with greater vigor than in the past, that is, action-oriented policies relating to population, employment, agrarian reform, nutrition, research, training, agricultural extension, and marketing, including the improved processing of agricultural products to make them more competitive in the world markets in their own right.

His major point is that there is a connecting thread running through all the matters that he has mentioned. This is the question of international agricultural adjustment, a concept which he believes ignores national boundaries and applies to the world as a whole; he recognizes that this subject is so complex that it is hard to know where to begin, but he does feel that agricultural policies can no longer be formulated in an exclusively national or even regional context. This raises questions as to the functions of various UN agencies, including the FAO, GATT, and UNCTAD, and leads him to conclude: "So convinced am I of the importance of this problem for world development . . . that I have decided to propose the subject of international agricultural adjustment as one of the main themes of the FAO General Conference to be held in 1973."

III

I now turn to the main pressures or problems around which I think discussions of agricultural policy, as well as actual efforts to bring about agricultural adjustment in the international field, will lie over the next several years. There are four:

1. The agricultural aspects of the international trade problem.
2. Problems relating to the improvement of agricultural and food technology in the developing world.
3. The staggering difficulties set by dense rural populations which continue to increase at a rapid rate or, more precisely, the problem of rural employment.
4. The environmental problem, about which the developed countries are now so much concerned but which must also be of concern to the developing world.

I shall not necessarily discuss these in the orde

of their importance; in fact they form a closely interrelated whole and must in the end be considered as such.

The agricultural aspects of the international trade problem. I start with this problem not only because H. C. Taylor as far back as December 1920 hoped that a revival of international trade might be the answer to the particular problem with which he was then concerned but also because it seems to me that American farm policy today is in considerable part still centered on this same hope.

As of now the temperate zone exporters, including the United States, are looking for new or additional foreign markets while the developing countries of the world, many of whom must chiefly depend upon agricultural exports as their principal source of much-needed foreign exchange, are equally interested. There is not much need for me to discuss this problem in great detail in view of the various studies or analyses with which I am sure most members of the Association are already familiar. There is, however, one school of thought which looks on the whole effort to find additional markets as a "zero-game"; that is, they feel that the international agricultural markets are relatively limited and that any increase for one country or group of countries must be offset by a decrease for someone else. I find it difficult to agree with this, although I recognize that international nonagricultural trade is increasing at a faster rate than trade in agricultural products. But we do know that international trade is increasing for quite a few agricultural commodities, for example, livestock products, coarse grains, and forest products. In fact export earnings in basic foods as a whole have been expanding for some time in the region of 4 percent per year; given appropriate actions by importing countries, possibilities for expansion in these and other products are substantial.

One of the chief factors to be considered are the possibilities of the major importing areas (the United States, the Common Market, the United Kingdom and the Associated Free Trade area, and the socialist countries, especially the USSR) opening their markets to increased imports and equally, of course, the question of where the added imports might come from. Many of the developing countries must chiefly depend on agricultural exports as a source of much-needed foreign exchange, but agricultural exports as a source of foreign exchange are also valued very highly by several of the smaller temperate zone countries (for example, Denmark and New Zealand) as well as some of the great industrialized countries who have balance-of-payments difficulties (for example, Australia and the United States). There is also the problem of preferences of various kinds and the question of how they can be negotiated, questions as to feasibility and usefulness of commodity arrangements or agreements, questions as to the place of food aid and concessional sales in the movement of commodities from surplus-producing areas, and questions as to how far and how fast the developing countries can or will move with import substitution as a means of saving foreign exchange if they find their export markets blocked.

For the time being, however, it seems to me that needed discussions with respect to these problems are delayed or blocked while most of the world waits for a decision as to whether or not the United Kingdom and two or three other countries become a part of the Common Market —a decision that recent news reports suggest may be forthcoming somewhat sooner than had been expected. There are also those who believe that even after this decision is reached some of the much-needed discussions will have to be deferred until the chief temperate zone exporters from the non-Common Market area will have come to some kind of working arrangements among themselves. In any event, there is a feeling that the international world should find means of moving ahead to bring about a satisfactory solution to these problems, as witness some recent statements by the Director-General of the GATT, as well as my own Director-General's recent discussion before the IFAP to which attention has already been called.

There are many questions as to what might be negotiated, as well as the modes of negotiating. As Malmgren recently indicated, there is the problem of a comprehensive approach which relates trade and investment as well as both internal and external adjustments; there is the problem of how to use existing or whether to establish new consultative procedures that will relate traditional bargaining to the need for harmonization of national policies; and there is the need for the definition of principles and guidelines to which governments might commit themselves and which could go well beyond present rules with respect to both specific products and problem areas (a field in which the FAO has done considerable work). In any event, it is certain that a discus-

sion of many of these problems, including a full statement of the views of the developing world will come to the surface at the Third General UN Conference on Trade and Development scheduled for Santiago in early 1972.

Problems relating to the improvement of agricultural and food technology in the developing world. In the article on "Some Problems of Agricultural Development," which appeared in the Journal for December 1969, I called attention to the fact that it seemed to me the main objectives of agricultural technology in the developing world should be, first, to assure the staple food supplies for a population typically growing 2.5-3 percent per annum and, second, to change the composition of the national diet to meet specific requirements of food policy, with special attention to protein. I also suggested that the target for the Second Development Decade would likely call for an increase in agricultural production of 4 percent per annum for the developing world, which compares with an average rate for the last decade of not more than 3 percent.

My main argument was that *"farming systems as a whole need to be substantially altered or redesigned over much of the developing world and that what is needed is an integrated or "package" rather than a "piece-meal" approach."* This means that in addition to developing the necessary package of practices, ways and means must be found for supplying the necessary requisites, including improved seed, fertilizer, insecticides, etc., many of which must come from outside. At the same time, ways and means must be found of motivating farmers to adopt the new practices or systems which, of course, means that there must be reasonable incentives, the credit and marketing system must be improved, and means of assuring minimum prices must be found; this leads to the conclusion that ways and means must also be found of assisting or motivating the governments of developing countries in giving the necessary priority to planning and actually carrying forward a sustained agricultural effort.

I think it is unnecessary to discuss further the detailed content of my earlier paper. The fact is that the populations of the developing world are continuing to increase 2.5–3 percent per year, and this is not likely to be substantially altered during the 1970's. It is also a fact that the so-called green revolution has substantially increased yields in a number of countries and has given new impetus to the concept of the package approach. Agricultural assistance should continue to receive a high rating in the developing countries under the new country programming procedures of the UN Development Program.

In my earlier paper I referred to some discussions of the possibility of increasing contributions for international research as a means of developing a scientific basis of production-oriented commodity improvement programs for some of the more difficult problem areas of the developing world. As a result of these discussions an International Consultative Group on Agricultural Research was announced last May. The Group, jointly sponsored by the IBRD, the FAO, and the UNDP, includes not only national governments and the three sponsoring international agencies but also the Ford, Rockefeller, and Kellogg Foundations, as well as the International Development Research Centre (a Canadian institution). The government members include Canada, Denmark, the Federal Republic of Germany, France, the Netherlands, Sweden, the United Kingdom, and the United States; and it is expected that some other countries, as well as one or more of the regional development banks, will also become members. The objective is to assist in synchronizing national and international agricultural research efforts and to consider the financial requirements for high priority international and regional research activities, keeping in view the need for continuity of research over a long period.

The Consultative Group will be assisted by a Technical Advisory Committee of twelve distinguished scientists with Sir John Crawford, formerly chief of the Bureau of Agricultural Economics of Australia and now vice-chancellor of the Australian National University, as chairman. The Committee will be responsible for advising the Consultative Group on the principal gaps in agricultural research and for suggesting or arranging for feasibility studies on what might best be done with respect to such gaps. The FAO is providing the secretariat for the Advisory Committee, while the secretariat of the Consultative Group is being provided by the World Bank.

Obviously the moving forward of activities to improve existing or developing new agricultural technologies for the developing world itself raises many problems in the field of agricultural adjustment, which problems will in turn be influenced by the success or failure of the new technologies. Indeed there are already a number of agricultural economists who are chiefly interested in

what they term the "second-generation" problems of the green revolution.

The staggering difficulties set by dense rural populations which continue to increase at a rapid rate or, more precisely, the problem of rural employment. This seems to me the most intractable of all the problems of the developing countries.[1] In areas or regions where the problem of hunger is most acute or at least a constant threat, ways and means must be found for increasing agricultural productivity while at the same time maintaining in rural areas most of the current populations as well as, if our Indicative World Plan forecasts are correct, a substantial portion of their annual increase over the years ahead. This leads a considerable number of people to insist that the greatest single problem is that of rural employment, but once again creating jobs by simply spreading work is not a satisfactory solution. Production must also be increased.

Our friends in the ILO estimate that the number of able-bodied workers in the developing countries is expected to increase from about one billion at present to about 1.25 billion by 1980; as there are some one hundred million people unemployed today, this would call for the creation of some 350 million new jobs by 1980 in order to fully employ the available labor force. Although the problem strikes at all sectors of the developing economies, it has to be remembered that about two-thirds of all able-bodied workers in the developing countries are still engaged in agriculture. Further, many of these, although technically employed, are nevertheless underemployed, while the population increase in the rural areas equals or exceeds that in the nonrural areas. Whatever solutions are worked out in many of these countries must be built around small farms and rural industries, as these rural populations are already moving to cities at a faster rate than they can be accommodated. This problem also of course underlines the importance of the whole question of population control, but this I am more inclined to put under my fourth and final head.

The environmental problem, about which the developed countries are now so much concerned but which must also be of concern to the developing world. I am sure that you all know that both the national and international communities are now preparing for a World Conference on the Human Environment scheduled under the auspices of the UN for Stockholm in June 1972, while plans are also being developed for the fourth World Population Conference to be held in 1974.

Perhaps the current interest in the environmental problem centers largely in the developed world, but it must increasingly also become of interest to the developing world. It is also a fact that agriculture, forestry, and fisheries have generally taken a lead over the last fifty years in

[1] This not only seems to me to be the most difficult of all the problems facing the more densely populated developing countries, but this and the following paragraph also seem to me to be the weakest parts of this paper. In this connection, it may be of interest to call attention to what I consider the best comment that I have received (from John H. Southern) with regard to these two particular paragraphs. That is:

"Solutions to employment problem [could] lie in these directions:

(a) As a general condition a "good" rate of economic growth must be maintained—or employment problem worsens and becomes intractable;
(b) Labor-intensive agriculture [probably will be small farms, but doesn't have to be] should be guiding policy; much of modern improved technology is adapted to this approach and labor is the abundant on-farm resource to be utilized in achieving highest production per area of land;
(c) In line with this guiding policy, eliminate distortions or biases [subsidies, pricing, tied aid, duties, trade union pressures, capital investment allowances, etc.] in the economy which favor capital-intensive technology, in particular labor-displacing mechanization [might recognize that too often mechanization per se has been the symbol of agricultural improvement]; on the other hand, use subsidies to maximize modern inputs that are *complementary* to abundance of labor;
(d) Move toward selective rural development [as opposed to overall "integrated" rural development] for job expansion through linkage with a system of rural growth centers;
(e) Carry out a large program of labor-using public works of a type to reinforce needed infrastructure for further development.

These lines of action make sense in terms of what countries and external assistance can do in the short run of the next two decades when the problem will be most severe. Of course, longer-run policies of population control, rational trade, general and sustained economic growth, etc. are necessary and not to be neglected in the short run.

Even with large programs of whatever kind, some countries face an insoluble problem in the short run. Then what occurs—is "work spreading" necessary? Industry can be a part of work spreading. Such could take many forms. [Also] how far can a subsistence society and culture absorb its own surplus population? The resiliency of these populations is astounding. Times and expectations may have changed, but a great deal of this problem will be absorbed in families, villages, groups, etc., in the sub-utilization of labor. What the critical or explosion point of this "nonsolution" will be is a good question."

conservation activities and that much of the current concern about the environment lies outside the agricultural field.

Nevertheless there are substantial areas where environmental actions now being discussed will affect agriculture (including forestry and fisheries). Our Fisheries people are considerably concerned; pulp and paper producers will have to change some of their methods; and the use of some chemicals for agricultural purposes and health protection measures will be increasingly questioned. DDT is a case in point. The WHO finds it most effective in connection with malaria control, while FAO feels it or similar chemicals must be used in connection with locust control. Nevertheless, the use of this and similar chemicals must of course be carefully watched and in many cases restricted. Also, the construction of large-scale dams and reservoirs are being increasingly questioned.

The Stockholm Conference will surely lead to a series of plans and proposals in the environmental field. Some of these will call for systematic data collection on pollution levels; for exchange of information among countries; for the study of the effect of environmental measures on the supply and demand of national resources on development opportunities; for increasing attention to the setting up of international standards or limits for chemical, physical, and biological contamination; for the promotion of scientific environmental oriented research, including the use of plant derivatives and biological methods to replace toxic chemicals for controlling pests; and for formulation of national environmental policies and plans to cover optimum land use and the achievement of such goals as control of "urban sprawl."

But what also interests me is the fact that a number of my friends look upon population, especially the continuing increase of already dense populations as one of the main challenges to our environment. I fully agree. Family planning or population control must be given high priority in any overall approach to the environment problem. I realize the essential difficulties and the time factor involved, and I am certainly not suggesting that current prospects for agricultural improvement are not such as to offer a decade or more of time to work on the problem, but the recent improvements in agricultural yields in the developing countries only buys us a little time; the problems of population growth will not disappear. I believe there is now increasing agreement on the necessity for family planning and a fair chance of considerable progress being made in the next two decades toward bringing the population problem under some degree of control.

Discussion: A. J. Couτu, Agency for International Development

There is little doubt that Wells has identified some of the major agricultural adjustment issues. However, he said very little on what options are available, particularly for U. S. agricultural economists. I would like to address my comments to present activities and future opportunities related to the complex issue of choices among projects, programs, and policies dealing with multiple goals of output, employment, income distribution, nutrition, and equity.

On the issue of a change in attitude by the developed world that seeks action-oriented policies, what is greatly needed is a vigorous substitution of many broad-brush and subjective so-called agricultural sector studies by substantive, analytical, and quantitative policy analysis efforts to systematically estimate the consequences of alternative policies, programs, and projects on multiple goals. In my judgment many developing countries would welcome:

1. Jointly designed, programmed, and implemented analytical type policy studies.

2. Participation of external analysts working with young well-trained but immature indigenous staffs.

3. Coordinated activities of international agencies in this applied research; in some countries they are overrun with short-term study teams, special commodity studies, and in general a series of three-month efforts that rehash the same descriptive and time series data. Some recent policy research activities of a substantive analytical nature are underway in selected countries.

With respect to increased international trade, to argue for bargained concessions without analytical economic intelligence is wishful thinking. Substantially increased applied research on quantifying regional, aggregates of regions, and international supply and demand functions is imperative. The options on in-country diversification and regional specialization are essential components. The need is not to build some super applied research institute on agricultural trade but rather to link analytical research types in institutions within the more developed world with those

in the less developed countries, to provide for professional seminars and workshops, and to publish the findings as research findings. Some efforts in Latin America, the Philippines, and Thailand are illustrative.

On the rural employment issue, basic empirical knowledge that may be highly location specific is not available. At least two suppositions need to be evaluated: (1) Have interventions into markets of many types distorted labor/capital price ratios, leading to a misallocation of resources ranging from overmechanization, excessive modernization, enlarged agricultural extension programs, piecemeal agricultural research programs, to overemphasis on water resource development? (2) Does the lack of knowledge on intermediate type technologies explain a majority of the resource use and income distribution inconsistencies? Are there forms of labor-using technologies, biological and mechanical, that are economically viable? If not, what thrust in research can be implemented?

Here again the instrument by international agencies should not be a wild rush for operational programs but rather a substantive commitment to analytical and quantitative research. Here is another area where such research must be jointly designed and implemented. Some work by ILO, AID/W, BID, and IBRD has been initiated on these issues.

Relative to the issue of increased agricultural and food technologies, the concerns for knowledge of trade and employment options is crucial. Other serious concerns include a recognition and search by biological and technical scientists for innovations that are neutral or positive (labor-using) to small farmers on rain-fed land areas with nominal developments in factor markets. The solutions do not all lie in subsidized factor- or product-pricing schemes; in tracking out and substituting for the "mafia" in performing assembling, processing, storage, or distribution functions; or in modernizing rural ownership units by vast land tenure changes, new water associations, etc. Rather the need is to find systems, through research, that will use abundant natural and human resources in an efficient manner, that are competitive with other types of systems in varying parts of the world. This type of research is not being performed in an adequate manner.

Towards these issues, it seems that we international agencies have not recognized two very substantial changes over the last 10–15 years: (1) that the multiplicity of development goals now requires knowledge of trade-offs; (2) that the increased quality of human research resources and increased commitment to seeking real development options consistent with multiple goals or minimum trade-offs offers the researchers in the more developed countries tremendous opportunities to join forces. Why persist in short-term projects designed to yield quick and highly visible results?

Discussion: T. C. KERR, Purdue University

Of the points raised in Wells' paper, it seems that the improvement of agricultural and food technology in the developing world should have been emphasized over the trade issue. First, if the major issue facing world agriculture is the provision of an increased food supply to ensure adequate diets for a rapidly increasing world population, this can be accomplished only by substantial increases in agricultural output in at least some countries in the developing world. Second, the international transfer of technology is altering comparative advantages in agricultural production, and the real costs of existing agricultural trade barriers cannot be adequately specified without prior consideration of potential changes in technology in the developing world. Third, to the extent that technology substitutes for natural resource endowment, successful international transfer of agricultural technology is a substitute for international trade in agricultural products. Therefore the benefits of negotiated decreases in trade barriers should be assessed in relation to the benefits (and costs) of technology transfer. Exceptions occur in respect to trade in tropical agricultural products and in several cases where prohibitive trade restrictions exist; for example, the world sugar agreement and various national dairy policies.

An important aspect of the trade, technology, and employment triumvirate may be the role of international firms. The international transfer of technology in industry has been very substantial in contrast to the limited success enjoyed in the transfer of agricultural technology. The former has been effected largely by international firms operating with governmental support (import substitution and export promotion policies) within the industrial sector. In contrast the public sector plays the major role in the transmission, adaption, and extension of agricultural pro-

duction technology. While the performance of the latter is somewhat suspect, success being limited to the green revolution, the combination of import substitution policies and the international firm may well be a major contributor to the current employment problem in the developing world. This may be explained through a divergence between social costs and the private costs to the international firms of developing a technology suited to the host country factor endowment. Given small markets, problems of training, research and development, it is reasonable to argue that this process may have resulted in transplanting an inappropriately capital-intensive industrial sector into the developing world. This would contribute to the employment problem, and it will only further increase equity and income distribution problems to react by inducing labor-intensive technology in agriculture.

Finally, it should be recognized that not all countries can have a comparative advantage in agricultural production. Natural resource endowment is heterogeneous within the developing world, and any analysis of agricultural trade adjustment will be severely deficient unless it considers the industrial sector as an alternate source of foreign exchange for the developing world.

Discussion: KENNETH E. OGREN, Foreign Agricultural Service, USDA

My comments are on the first of four problems in Wells' paper—the agricultural aspects of the international trade problem. I agree that U. S. farm policy is in considerable part still centered on the hope expressed by H. C. Taylor that a revival of international trade can provide the answer to agricultural adjustment in the United States. President Nixon in a recent statement enunciated a goal of 10 billion dollars in U. S. exports of agricultural products.

My thesis is that despite the substantial increase in U. S. exports to a record high level in 1970 following three years of decline, the prospects for achieving *political* solutions to the agricultural aspects of the international trade problem have generally worsened in the last several years, and there is little reason for optimism in the immediate future.

As a yardstick to measure the deteriorating environment of recent years, I would like to contrast the references to agricultural trade problems in reports of two Presidential commissions, the Food and Fiber Commission (mid-1967) [2] and the Commission on International Trade and Investment (mid-1971) [1].

The Food and Fiber Commission gave much attention to food aid and problems of economic development, more than it did to foreign trade problems. Its report was developed before the green revolution and contains phrases such as "imminent threat of famine in large parts of the globe." It referred to the Kennedy Round as the first successful effort to link agricultural and industrial trade negotiations in the 20-year history of GATT. U. S. agricultural exports would be trending upward without the new trade arrangements (the report said), but the results of the Kennedy Round should result in significantly faster expansion. With regard to the CAP policies of the European Community, there were no recommendations or especially critical statements. At the time of this report (1967) our agricultural exports to the Community were still increasing for variable-levy products as well as for others.

The more recent Commission, in contrast, deplored the lack of progress in agricultural trade problems made in the Kennedy Round. Its concerns focused on the agricultural policies of the European Community. The key to progress, its report stated, lay in changes in Community policies: "The United States should immediately and vigorously assert its agricultural interests in bilateral discussions at the highest political level with all parties to the proposed enlargement of the European Community."

As to the future, the more ardent supporters of European integration are optimistic that the British, once in the Community, will exert a beneficial influence in lowering price support levels. U. K. actions in recent months give little support to this optimism. On the side of the Six, the EC Commission is now proposing further price increases for grain of about 3 percent for 1972–1973 on top of those just granted for 1971–1972.

To unlock the impasse on agricultural trade problems, a comprehensive approach in negotiations is needed that includes trade, investment and monetary issues, agricultural and nonagricultural products, internal as well as external problems of adjustment to economic change. The tensions that now exist among the major trading na-

ions are not an auspicious sign for the future; one can only hope that these nations will recognize the growing interdependency of their domestic as well as foreign economic policies and act accordingly.

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Discussion: HARRY E. WALTERS, Economic Research Service, USDA

I should like to confine my comments to two issues raised in O. V. Wells' paper: What is needed to effect agricultural adjustments; and the link between very small farm size and the problems of improving agricultural technology and generating rural employment while providing some degree of equity in developing countries.

Desirable as it might be to feel that "agricultural policies can no longer be formulated in an exclusively national or regional context," the fact is they are. After all, these are national or regional political solutions to real or felt national or regional problems. We should assume that those who established these policies are at least reasonably well aware of their internal and external impacts. We also have to assume that the costs of existing policies were weighed against the alternatives apparent to political leaders. I am not too hopeful, therefore, that admonitions for a broader world context for agricultural or trade policy formation, or new "modes of negotiating" or "consultative procedures" will accomplish the adjustments suggested in Wells' paper.

Few people quibble in principal over the rich helping the poor. Many have expressed sympathy for the desire to "eliminate or reduce tariff barriers," and "allow increased export markets for developing countries." What is missing is the analytical evidence to provide political leaders with a clear and unavoidable indication of the costs of present policies and a basis for selecting alternatives. What are the opportunity costs (economic and social) of people and resources presently supported or protected in different countries? What are the costs of alternative policies that would solve national political problems and yet provide freer trade and more developing country export markets? Who has what comparative advantages? Without such analysis, which the agricultural economist should be well suited to provide, it seems unlikely to me that national or regional policy-makers will be receptive to abandoning their present policies.

I think we have not really grasped the difficulties imposed on transferring agricultural technology and generating employment in developing countries where a large segment of the farm population exists on very small farms (from less than one to five hectares). Despite the examples of Japan and Taiwan, the green revolution, and my personal feelings of optimism, raising agricultural productivity, increasing employment, and doing both with some reasonable degree of equity will be very difficult in these areas. It is one thing to devise special "package" programs, supply seeds, credit and extension services, and to provide markets for a few favorably endowed farms in these countries, but quite another thing to extend these services and programs to the large number of small farmers.

Our experience provides us with pitifully little knowledge of what technologies to apply and how to apply them to these farms. Customary extension and credit programs imply a trained manpower and resource effort vastly larger than it is reasonable to anticipate in the foreseeable future. There is considerable doubt about the costs, productivity, and efficiency of these farms now, let alone a decade from now when there will be more farmers and less land.

Many of the current proposals for generating additional rural employment—road building, public works, infrastructure—seem to require mechanisms for allocating the unemployed or underemployed labor resources, which do not exist in these countries. As in the case of the adjustment problem, we need more hard research on what works or does not work and what the economic and social costs of alternatives are. For example, what labor-intensive methods are also efficient? How can credit and extension services be efficiently extended to farms with one, two, or three hectares of land? How can inputs be supplied and outputs marketed efficiently from such farms?

Development and Trade—Is There a Conflict?

CHAIRMAN: REYNOLD DAHL, UNIVERSITY OF MINNESOTA

Discussion: LAWRENCE V. WITT, Agency for International Development*

AT THE risk of trespassing on the other discussion group I suggest that equity and income distribution are areas of conflict in this discussion of development and trade. I stress this as a largely ignored problem in Wells' otherwise comprehensive paper, one that will take on increasing importance during the next decade.

Programs to enhance self-sufficiency are common within the development strategies of many LDC's. As you know, a short-run result of the usual implementing techniques is higher prices for the affected commodities and often some income gains to groups who already are doing well. But what are the longer-run effects on development and upon equity among nations? The answer may turn partly upon whether it is a DC or LDC whose products no longer find a ready market and upon complex imponderables about the real alternatives to self-sufficiency.

Self-sufficiency programs among the wealthy nations clearly make export stimulation programs less attractive to the LDC's. What effects do they have upon the development of the wealthy nations and upon world development? It can be argued that many of the protective devices, and not only in Western Europe, stem from the role of the small-scale and marginal farmer in public policy, and have short-run benefits to them. For the longer run the internal equity advantage disappears, particularly if you assume that with lower incomes many more farm youth would have migrated from agriculture. But for the LDC desiring to export the implication is clearly against equity, against trade expansion, and against greater development in both the short and long run. Does this issue, rather than what England's accession to the Common Market means to Canada, New Zealand, and American Agriculture, deserve more attention?

The persistence of this situation is the basis for the general assumption, expressed in Wells' paper, that aid not trade is the major way to face the development challenge. If the wealthy nations were to seriously support a program to encourage imports from the LDC's and spend some of our present foreign assistance funds to ease the adjustment at home, would there be more development and more equity internationally as well as internally? Does the lack of strong political support for foreign aid make trade potentials a question deserving more analysis?

A related issue: Is it socially legitimate to argue that the increases in domestic markets, or a major share of them, "belong" to the already protected U. S. producers? A good argument can be made that equity and development urge that most of this expanded market should be made available to the LDC's. This situation, which in an open world economy is more than a "zero-sum" game, can become a zero-sum game in a world of quotas, commodity agreements, etc. If our own moral sensitivities support letting LDC's supply much of the expanding market, particularly when they have a comparative advantage, then trade and development become more congruent; if not, the LDC's lose much of the strength of "trade as an engine of development." What can we do as economists to support a more enlightened position on this issue?

Finally, I can do nothing more than underscore Wells' reference to the "staggering difficulties" posed by rapid population growth. Is there no way in which more rapid action can be taken to counteract this grave threat to equity, to trade, and to development?

* These comments and questions do not necessarily reflect the views of the Agency for International Development.

Discussion: TAE-HEE YOON, International Bank for Reconstruction and Development

This discussant agrees with Well's views and consequently intends to offer some supplementary comments on one of the main issues raised in his paper—rural employment problems of developing countries, with particular reference tc their policy implications.

Despite the widely publicized success of the green revolution in some parts of the world, the

need for increasing output and per worker productivity in the agricultural sector of developing countries clearly remains. Resource requirements for economic growth in the seventies and other public mandates in the areas of employment, distribution, poverty, nutrition, education, etc. will continue to fall beyond the capacity of the developing countries. Both the current philosophy regarding foreign aid and the tendency toward a new protectionism threaten the external resource prospects of poor countries. However, they seem to have no option but to rely mainly on trade.

Some legitimate economic grounds for opposing the theory of comparative advantage, from the developing countries' point of view, include: (a) the infant industry argument; (b) short-run instability in export markets; (c) secular decline in terms of trade for primary products; and (d) disparity between social and private costs.

On the other hand, the economic losses from the abuse of the above arguments may often be greater than the gains. Given the current and future rural unemployment problems in many labor surplus developing countries, it seems imperative that these countries pursue growth policy along the line of comparative advantage that would lead to economic exploitation of surplus labor. A development strategy along this line would require many extraordinary measures, but in particular the following: (a) adjustment of export agriculture, particularly labor-intensive sectors, to create larger export-oriented employment and foreign exchange for domestic investment; (b) correction of factor-price distortions, including undervaluation of foreign exchange, low interest rates combined with administratively allocated credits, disparities between wage rates and the social costs of labor, and overprotection of domestic manufacturing industries; (c) adoption of appropriate price policies toward domestic products and factors to ensure a reasonable return to the labor-intensive commodities and the timely supply of inputs to small farmers; (d) institution of effective fiscal systems to tax excess profits of favored groups and to generate sufficient public revenue necessary to achieve redistributive justice; also to reallocate resources toward mobilizing unemployed and underemployed labor, including the provision of incentives for labor-using technique through public subsidy; and above all, (e) measures for effective population control, necessary as a long-run measure in most labor-surplus economies.

The contributions that can be made by the development institutions toward greater economic utilization of surplus labor include: (a) reducing so-called capital-intensive bias inherent in aid projects, through a more systematic and comprehensive exploration of employment opportunities; (b) encouraging the developing countries to adopt the specified policies through strengthened dialogue with them; (c) supporting agricultural and economic research activities in labor-intensive rural employment and agricultural production; (d) reducing the political ties associated with aid; and (e) promoting reduction of world trade barriers to allow developing countries to exploit their comparative advantage in labor-intensive industries, particularly in the agricultural sector.

Production and Equity—Is There a Conflict?

Chairman: Wayne Schutjer, Agricultural Development Council

Chairman's Comments

The issue of distributive justice and agricultural development raised by O. V. Wells has demanded increasing attention among agricultural economists. At the aggregate level the historical record from the Western world seems clear: as GNP increases, income distribution becomes more equal [4]. The basic reason for the positive relationship between aggregate growth and income distribution is the structural transformation in national product that accompanies economic development[3].

The role of increased agricultural output in stimulating and facilitating increased GNP has been conceptually developed and historically documented [1, 2]. Thus at the aggregate level increased agricultural output appears to lead to a more equitable income distribution. In short, at the aggregate level there is no conflict.

Within the agricultural sector, however, there is a conflict between increased output and income distribution. The conflict stems from the essential nature of the agricultural development process. Agricultural progress requires the introduction of new technology which in turn is often available only in the form of purchased inputs suitable for use under limited agro-climatic conditions. As a result, regional income disparities are inevitable, if only because of the uneven development of agricultural technology suited to particular geographic areas. However, more important distortions occur because of unequal access of various groups in society to knowledge regarding the improved inputs and to the resources required for their purchase and use. As a result, the marginal value product per dollar of investment in agriculture is likely to be substantially greater if investments are concentrated in the appropriate agro-climatic regions and used to complement the resources of the few.[1]

Distortions in regional and personal incom distribution stemming from increased agricultural output will be greater in a culturally anc geographically diverse nation characterized by ar initial skewed geographic and personal resourc distribution pattern. In addition the distortion will be more severe in the short run and unde conditions where high priority is placed on increased agricultural output.

In the short run a strategy that emphasize working with resource-rich farmers will enhanc their relative position (in some case absolutely vis-a-vis the farmer who has access to fewer resources. The initial adverse effect on income distribution will be partially offset by forces pu into play by the increased output.[2]

In countries where the quality of the agricultural resource base varies significantly among regions the conflict between growth and equity i clearly magnified. Similarly in nations characterized by a considerable degree of cultural and geographic diversity new agricultural technolog will have less general applicability, new idea about farming will spread slower, and equilibrating factor flows will be hindered.

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[1] This assumes that adverse income distribution does no create such a degree of political and social instability as t retard growth significantly.

[2] The argument, which is conceptually similar to Hirschman's unbalanced growth notion, has been developed i relation to agricultural investment priorities in [5].

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Discussion: WILLIAM C. THIESENHUSEN, University of Wisconsin

I think it is reasonable to expect farm production increases in most Latin American countries during the 1970s. As the green revolution spreads to more crops it should buy the time necessary to control population growth. But the technology that makes the green revolution possible will almost certainly exacerbate the already high unemployment rate and skewed income distribution pattern if present rural institutions remain unchanged.

My hypothesis is: Where distribution of agricultural resources is highly inequitable (as in the hacienda system), introduction of new technology needed to increase production is more likely to increase the income gap between rich and poor than in areas where agricultural resources are more evenly distributed (as in India and Pakistan).

The immediate effect of yield-increasing inputs in Latin America is to add to the incomes of the already rich, the *hacendados*. Seeds and fertilizers are not in fact neutral to scale in most of Latin America because credit institutions and those that are charged with diffusing technical information are usually designed for the large-acreage farmer.

The green revolution may in the short run have one favorable impact on *minifundistas,* resident farm laborers and landless laborers: markedly increased yields may require more labor.

A major part of the technological advance of the fifties and sixties has taken the form of the introduction of labor-saving capital which has its greatest unfavorable influence on landless labor (the majority of Latin America's rural work force) and those *minifundistas* who must work on large farms to supplement their incomes and who now may be out of work or underemployed.

Though yield-increasing and labor-saving technology are separable in theory, they often become quite interdependent in the longer run. This portends more mechanization and further depression of employment opportunities at the low end of the income spectrum. For example, in some instances green revolution varieties may need such precision seedbed preparation that mechanical methods become mandatory.

Eventually those who depend solely on their *minifundio* for subsistence may suffer also. As domestic markets fill, prices for the commodity will drop. Farmers who have not been able to adopt the new technology will likely find that they have no chance to make up in quantity what is lost in price. The landholder will probably be able to deny windfall profits to tenants too. Because there are so many potential renters, a landlord can raise the share he demands or his lease price.

It would seem that the only way to mollify these problems is to modify with a massive land reform the traditional Latin American latifundia system. There is increasing evidence that it is possible to get as much marketable surplus from campesino agriculture as from land tenure forms that concentrate resources excessively. This lessens any conflict there may be between production and equity. But more research is needed to determine how service, credit, and marketing institutions should be reoriented so that inputs and knowledge of how to use them become widely available to compesinos.

Discussion: WILLIAM O. JONES, Food Research Institute, Stanford University

If equity is what is fair and just and if we choose to believe that it is fair and just that those who produce more should receive more (that those who will not work shall not eat), there is no conflict. More currently acceptable concepts of equity, however, suggest that the conflict is deep-lying and unlikely to be fully resolved, even in a utopian long run.

Production versus equity is an ancient debate. What again brings it to the fore in discussions of international agricultural adjustment? The concern seems to take two principal forms: that as agricultural output expands in one part of the country, other parts will be left relatively, perhaps even absolutely, less well off than they were before; or that if agricultural output is increased by methods that can be employed only by a small fraction of the farm population, those who cannot employ these methods will be left less well off than they were or than they might have been.

Achievement of absolute equity, however de-

fined, and of maximum productivity are probably incompatible goals. At the same time some increase in productivity may prove to be necessary for any increase in equity, and some tendency toward equity may be essential for improvements in productivity. We must not be carried away by arguments that stress the productive advantages of particular policies and ignore their impact on equity. The interaction between production and equity is illustrated by the concept of "just price," which provided a reasonable basis for valuing goods and services in societies where "trade was still sufficiently haphazard to make it necessary to enforce regulations that would ensure as steady a supply of goods as possible." The just price then was not only equitable; it was also a productive price.

Change inevitably means that some will be less well off, absolutely or relatively, than before. Whether absolute or relative, if the population seriously doubts the equity of new arrangement: it may overthrow them.

In many of the poorer countries of the worlc agricultural development policy for some time t come will be compelled to temper the drive fo maximum output with concern to provide contin uing and increasing employment in agricultur whether from considerations of equity or of eco nomic and political costs to the society. In th longer term, however, the source of higher in comes for the populations of these countries i not to be found in farming but in other produc tive activities. As this basic structural transfor mation of the economy proceeds it is inevitabl that many will suffer while others prosper. Con siderations of equity may not completely go t the wall, as they tended to do during the Indus trial Revolution of the West, but they must fre quently take second place.

Contributed Papers
(Abstracts)

CO-CHAIRMEN: MERTON BADENHOP AND DAVE BROWN, UNIVERSITY OF TENNESSEE

Comparing Agricultural Adjustments and Policies via an Agricultural Sector Simulation Model

M. L. HAYENGA, T. J. MANETSCH, A. N. HALTER, T. W. CARROLL, D. R. BYERLEE, M. H. ABKIN, K. Y. CHONG, AND G. L. JOHNSON, MICHIGAN STATE UNIVERSITY SIMULATION TEAM

A MULTIDISCIPLINARY research team at Michigan State University recently developed a computer simulation model of the Nigerian economy which might allow more complexities to be considered in agricultural sector planning and policy-making. This paper summarizes the general model structure and illustrates its potential usefulness by simulating and comparing five agricultural policy alternatives for Nigeria. While the results must be considered tentative, they illustrate the model's use and provide some insights into likely agricultural adjustments under the postulated conditions.

The major model components are the Northern annual crop-livestock submodel, the Southern perennial and annual crop submodel, and a nonagricultural submodel. These are linked together to simulate the behavior of the Nigerian economy over time.

Five agricultural policies were arbitrarily selected and experimentally simulated from 1965 to 1993:

(1) a status quo agricultural policy;
(2) a 25–30 percent increase in marketing board export crop prices;
(3) a 10-year export crop modernization program for groundnuts, cotton, palm, rubber, and cocoa;
(4) a combination of (2) and (3) above;
(5) a 10-year food crop modernization program in the Nigerian Middle Belt.

While all five simulated policies resulted in substantial increases in gross domestic product, the export crop modernization programs apparently would cause a more rapid rate of growth, especially beginning approximately 12 years after the programs began. The diffusion of innovation naturally proceeded more slowly in the perennial sector.

Marketing board policies that will return all marketing board surpluses to the producer would likely result in a substantial boost in export crop production, gross domestic product, and agricultural worker incomes in the first decade of the program (early in the North, later in the South). By improving producer export prices and introducing improved export production technology and management, the greatest growth in gross domestic product, agricultural exports, and returns to agricultural resources was stimulated. These complementary policies instigated greater export crop acreages and yield increases than either policy did independently.

By modernizing food crops in the middle belt of Nigeria, little positive impact on gross domestic product, agricultural exports, and value added in agriculture was noted relative to current policies. However, the price of food exhibited a dramatic decrease and the caloric intake of the nonagricultural population increased substantially compared with the other programs considered.

To summarize, these illustrative policy runs provide some insight into the differing impacts over time of perennial versus annual crop policies. Regional impacts were strikingly different in the food crop modernization policy that was simulated. The multiplier effects of these policies (or effect on nonagricultural growth) varied directly with their impact on real agricultural output, incomes, and food price. When agricultural incomes changed primarily because of changes in food price levels, the multiplier effect was negligible because of the countereffect that a food price change had on the nonagricultural population's real income. Other price or output changes caused a stronger multiplier effect in direct relation to the effect on agriculture. In addition, the complementarity of some policies was aptly demonstrated in one case. Simulation appears to be a reasonable way of policy experimentation to avoid the price society may pay for policy mistakes.

Production Response to Technological and Price Changes: A Study of Wheat and Cattle Farming in Southern Brazil

J. J. de C. Engler and I. J. Singh, Ohio State University

This paper analyzes the impact of the price changes on resource allocation on representative wheat and cattle farms in Southern Brazil with the help of a programming model that includes alternative production, sales, and investment activities under various technologies. More specifically, it evaluates the possible impact of changing the support prices of wheat now maintained under a program to stimulate wheat production in Brazil.

Optimal and parametric results for short-run and long-run price changes show that under current support programs a wheat-soybean combination will continue to replace livestock production and that attempts to reduce support prices would lead to a transition away from wheat to soybean production or livestock production on improved pasture. Analysis of resource use shows that there is a seasonal unemployment and scarcity of labor and that cash use is not sensitive to changes in the short run. The internal rates of return to capital use also indicate that current interest rates charged to farmers are very low when compared to capital productivity and are being heavily subsidized.

Disequilibria in Developing Economics: Old Problems and New Priorities

William J. Staub, Economic Research Service, USDA, and
Melvin G. Blase, University of Missouri

The diffusion of modern farming practices into many developing countries offers potential solutions to many existing problems. But the introduction of these practices also has highlighted and exaggerated already existing disequilibrium conditions in developing countries. Primary among these problems is the dual-faceted problem of income distribution. While the distribution of benefits among economic groups within regions has been less than egalitarian, the exaggeration of income disparities among regions may be the more serious of the two.

In areas in India where the new technologies have been applied, small forms can and do adopt the new practices along with large farms when conscious efforts are made to enable the operators of small farms to purchase the required inputs. Further, in these areas substantial increases in employment opportunities for hired agricultural labor occur as well.

In northwest India the adoption of modern farm practices has been accompanied by a rapid adoption of farm machinery. Such implements, however, have been adopted primarily by relatively large farmers in areas where hired labor is relatively scarce, particularly in seasons when the demand for farm labor is greatest. Further, data from one district where tractors have been adopted by many farmers show that the use of tractors and other implements under certain circumstances may simultaneously enhance farm production opportunities and farm employment. Others may be incompatible with a labor-intensive agriculture.

Recent increases in farm productivity have been regionally and cropwise specific. Regions in which the preconditions for rapid agricultural development were already present have been most significantly affected by the new production technologies. Further, the greatest advances have occurred in wheat production with smaller but not insignificant advances in rice production. Areas where these crops are not widely grown or where assured water is not available have in general been little effected by the new production practices.

The new production technologies, because of regional differences in their application, may tend to exaggerate already existing disparities in income between developing areas relative to those in which little economic development has occurred. Continued unemployment, underemployment, and low incomes in resource-deficient areas may have external effects in developing areas. Migrations from the former to urban centers and developing rural areas are an example. Among other questions raised by regional disparities in the level of economic development, national leaders will have to decide whether it is better for a country to permit regional income redistribution to occur through regional redistribution of (1) the population, (2) production resources, or (3) some combination of the two. Research to discover yield-increasing technologies that economize on the use of the scarcest resource in less rapidly developing areas may do much to minimize differences in income levels between regions.

Much of the progress in increasing food production in the developing countries has been due to large investments of capital and knowledge by the developing countries themselves and the international development community. As members of the latter we would do well to realize that the distribution of modern farm practices may have an effect on the entire economy far beyond a simple production effect. Many of these effects are highly desirable while others are not.

Dairy Marketing Modernization as a Means of Nutritional Improvement: Some Developmental Considerations

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IMPROVEMENT in human nutrition is increasingly cited as an objective of international assistance programs. Successes in expanding foodgrain production have allowed consideration of the composition of food intake and human effectiveness in physical and mental activity. Nutritionists of both the agricultural and medical schools exhibit a strong attachment to milk consumption, with sound biological and pathological reasoning. Agricultural economists concerned with the level and distribution of rural income justify dairy development with reference to high income and price elasticity of demand for dairy products and labor intensity of the enterprise.

Unfortunately, bulkiness and perishability of the product impede realization of these gains. Reliance on international transfer of transport and processing technology in India has resulted in a generally poor economic performance. While geographically expanding market access, modernized fluid milk marketing systems are not competitive with old established milk marketing systems and fail to achieve wide distribution of nutritional benefit to segments of the population in greatest need. Transfered capital-intensive processing and packaging systems have been supplemented with labor-intensive procurement and distribution arrangements. Resulting improvement in labor productivity has been minimal despite extremely large increased investment per unit of labor employed.

Reliance on the reconstitution of concessional nonfat milk powder imports to improve plant utilization and nutritional performance is hazardous owing to instability of supplies. Unavailability of supplies would seriously jeopardize the existing modern systems.

Dependence on foreign equipment and financial support aggravates the resolution of conflicting objectives in public sector enterprises, particularly with respect to increasing milk consumption in low-income communities and achieving public and private employment objectives.

Capital-intensive technological innovation in marketing systems in many less developed countries poses a greater employment threat than such innovations in agricultural production. Displaced agricultural labor may be of the disguised form or likely shift to agricultural trade. Displaced labor from the long-established traditional marketing systems may enter the urban labor pool.

The competition that causes rapid innovation in the European and United States food processing equipment industry does not prevail in developing countries, with the consequence that individual firms may recommend transfer of newly obsolescent equipment, thus extending production runs. Under these circumstances firms may be reluctant to support recommendations to developing countries with appropriate examination of technical and organizational requirements. Institutional innovations are required to ensure that national and international aiding institutions, in cooperation with private industry, are oriented to servicing current needs in developing country agricultural markets rather than engaging in the creation of demand for new food forms and technologies. Past programs in dairy development have assumed a high degree of transferability of food consumption habits and preferences. Ready acceptance of such changes is not characteristic of communities in need of nutritional improvement.

Certain countries, such as Cyprus and Lebanon, have achieved large increases in per capita milk consumption through dairy product imports. Dairy development for import substitution in these countries could reduce milk consumption among low income groups, with resultant deterioration in nutritional status accompanied by a narrow distribution of consequent agricultural income gains.

Taxation of Rice Exports and Economic Development in Thailand

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There are divergent points of view in the analysis of the external and internal incidence of Thailand's export tax on rice. In he area of external incidence there is the theoetical argument that since Thailand produces nly 4.5 percent of the world rice production, hailand has very little effect on the world price f rice, and the incidence of her export tax is alnost totally domestic. The opposing argument is hat Thailand exports 20 percent of the rice in vorld trade and consequently Thai authorities an exert some degree of market power on prices nd a substantial part of the incidence of the export tax falls on foreign countries. The conflict bout the internal incidence of the export tax reolves around how heavily the burden of the tax alls on the farmer.

Many of the factors that make Thai rice prices nfluential in the world market are nonquantifiale, but a very rough estimate of the incidence of he tax that falls on Thailand would be 50 perent in the short run and 75 percent in the long un. In the short run Thailand's market power is mportant and exporters such as the United tates and Mainland China follow the market rice. In the longer run supply and demand vould be adjusted in both importing and exporting countries, but there is a continuing low elasticity of substitution between long-medium and round varieties (long-medium is a separate market). The market is also not complete, even in the long run, and there are a larger number of producers outside the market system.

The amount of domestic tax incidence that falls on the producer remains a mystery; truly rural markets would have to be sampled and the prices correlated for this determination. Data calculated for Bangkok would tend only to support the contention that the producer would take 50 percent of the *domestic* tax incidence from a decrease in the premium; at least this figure does not seem too high.

Since the premium is beneficial to Thailand relative to other countries, it aids in the economic development of Thailand. For an overall evaluation of the premium the other benefits and costs must be determined. On the negative side are the discouragement of rapid increases in rice production and an export economy bias. On the positive side are an industrialization bias, an import substitution bias, and a crop diversification bias. Given the institutional setup in Thailand, the premium seems on the whole to have been beneficial.

ORGANIZING AND FINANCING AGRICULTURAL PRODUCTION IN THE 1970'S

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The Emerging Food and Fiber System: Implications for Agriculture*

MARSHALL R. GODWIN AND L. L. JONES

FEW statements of certainty can be made about the U.S. economic system. One is that it will continue to undergo change and evolvement. While this process is the wellspring of material progress, it also is the generator of adjustment problems. Perhaps more than any other sector of the economy, agriculture has been involved in the process of change and adjustment for several decades. A central theme of this process consists of the increasing capability to produce the food and fiber supply on farms that are larger in size and fewer in number. This gives rise to two types of adjustment problems, one related to the attrition of farm units and the unemployment of people and resources no longer needed to provide food and fiber and the other to the survivors—the farm firms constituting the future production base. Our concern here is with the latter group, conventionally referred to as commercial agriculture.

This paper examines some forces of change that have major implications to commercial agriculture in the United States. It consists essentially of a base statement in which these forces are identified and briefly examined and is intended to serve as a point of departure for a more extensive discussion of what these forces presage in terms of needed adjustments in the future. It should be clear that confinement is a major problem in a paper of this type. An examination of the full array of change forces simply is not possible; consequently, there is no choice but to deal with those that have major adjustment implications in terms of setting the context of the future markets for agricultural products and influencing the configuration of commercial agricultural production and marketing operations in the years ahead. Forces we identify are pervasive and not of recent origin. In fact, some have been discussed by others [3]. We hope to set these forces in a perspective that will provide insight into the future direction that the food and fiber system likely will take.

Exogenous Forces

Certain basic forces affecting commercial agriculture originate in the broader economic and social tableau to which it is linked. In our view three developments have major significance: (a) the emerging attributes of the distribution system for food and fiber products, (b) the advent of synthetic and substitute foods and fibers and the new distribution systems which these entail, and (c) the changing public view of agriculture.

The emerging distribution system

The food and fiber distribution system must be responsive to final market demands. While this is an elementary observation it also is the root cause of the past changes in the system and the driving force for even more change in the future. The demand structure for food and fibers in the U.S. market has an increasing service component. Many services previously performed as a part of the household routine are being shifted onto the distribution system. This transfer process can be expected to continue. Part of the shift can be attributed to rising national affluence; part is due to a larger share of the female population entering the labor force; part also is due to changes in value systems that give higher priority to freedom and flexibility in individual activities and to leisure time. The shift has been fostered, in fact promoted, by the increasing capability of the distribution system to efficiently build more services into products. For all of these reasons the opportunity costs of performing an increasing number and variety of services in the home exceed the money cost of obtaining them as

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a part of the product-service package that the system delivers.

Tangible manifestations of what is happening take forms such as no-iron fabrics, food products for home consumption that require minimal and in some instances no preparation, and substantial growth in the share of the food supply that is consumed in restaurants, cafeterias, and in other institutional settings outside the home. As a result of the last, food converters are becoming an increasingly important component of the food processing system. These are the end results of the system's response to the increasingly serviceladened demands of the marketplace.

The increasing service orientation that is becoming prominent in the final demand for food and fiber products requires more dynamics in the distribution process. A continuing onflow of new and different product forms and techniques by which products are delivered to consumers is becoming an integral part of competitive performance of the distribution system. This performance requirement will continue to be a major determinant of the structural and operational configuration of firms and subsectors within the system.[1]

The performance requirements imposed on the distribution system have moved many firms and some commodity subsectors well along the way to industrialization. While industrialization has never been clearly or fully defined, the major elements involved are evident. They are specialization in effort, substitution of capital for labor in production, uniformity of quality in product output, the increasing use of science and technology in production processes and in managerial operations, and the consolidation and organization of resources to achieve the scale necessary for operational efficiency [19]. Industrialization is thus a process whereby an increasing quantity and variety of resources are subject to central coordination and control. The consolidation process has both vertical and horizontal dimensions.

Progress toward industrialization has been uneven among firms within subsectors of the distribution system and between subsectors as well. On balance, firms and subsectors in food distribution seem to have moved further in this direction than those for fibers. Particularization of where and to what extent the industrialization has taken place would largely entail covering old ground and is not essential to the central point here. The point is that it is highly probable that food and fiber processing and distribution firms and entire subsectors will move even further and faster toward industrialization and that this will require the orchestration of a widening array of resources and activities. In part this will be accomplished by growth and consolidation to produce a scale and diversity of firm operations well beyond the level that exists today. An alternative method by which it can and will take place involves an increase in the number and sophistication of interfirm arrangements to achieve essentially the same ends. To an increasing extent these interfirm arrangements will involve the fusion of decision processes and closer linkage of distribution firms. This linkage probably will move fastest in the vertical dimension, but substantial horizontal linkage also can be expected. The system is undergoing a process of enclosure and is evolving into one in which there is increasing proclivity and capability for coordination and control in both vertical and horizontal directions.

As this process intensifies, substantial change can be expected at the point of interface between the distribution system and the commercial agricultural establishment from which it obtains raw product supplies. The motivation for change will be the industrialization taking place in the distribution system and the accompanying requirement for coordination and control. The manner and rate at which change occurs will be determined by the power balance within subsectors of agriculture, and this balance appears to be heavily on the side of the processing and marketing firms that use raw agricultural inputs. Hence producers can anticipate increasing pressure from firms positioned forward in the distribution system—pressure which signals the need for more orderly supply flow processes, increased product uniformity, and greater stability in raw product prices.

Along with the quest for efficiency and equity in the market, these have long been objectives of commercial agriculture. But in the context that they are placed by developments in the distribu-

[1] This contention runs somewhat counter to that of Farris [4] and others that the firms in the distribution system are in a position to manage consumer demand to their own ends rather than one of responding to it. Neither view may be totally correct; the performance requirement may be generated partially by the emerging final demand and partially as a result of the manipulative actions of marketing firms. Regardless of its origin, the implication of the dynamics involved is the same from the standpoint of performance requirements of production agriculture.

tion system they should take on a new meaning, for they entail a degree of sophistication in agricultural production and marketing operations that few producers now envision. And they entail a heightening degree of response urgency on the part of the production establishment.

Impact of synthetics and substitutes

Changing consumer desires toward increased demand for service-ladened food and fiber products is accompanied by improving capabilities to modify and create new and different products through technological innovations. This adds another dimension to the emerging food and fiber system that has implication to commercial agriculture. Increasingly, opportunities are created for supplying consumer's food and fiber demands from alternative, "nonagricultural" sources. The availability of synthetics and substitute food and fiber products is not new, particularly in fiber markets, but only recently has it posed a serious threat on a broad front as a potential competitor with conventional agricultural products in food markets.

The impact of nonconventional food and fiber supplies on commercial agriculture varies, depending upon the source of raw materials. If raw materials come from outside agriculture the impact is one of direct displacement of output from the agricultural subsector involved; its market share is threatened and total industry income may be reduced. An illustration of this type of impact is provided by the incursion made into the U.S. fiber market by synthetics, a gain of about 26 percent in market share in the past ten years. Mills have become linked to supply sources that are entirely outside of conventional agriculture. The potential for growth in these types of products appears to be largely in nonfood markets, such as animal feeds, and further inroads into the fiber markets.

A different effect results if substitutes are derived from materials within conventional agriculture. Growth in production of such products may decrease demand in some production subsectors but increase demand in others. While the total value of output may remain unaffected, traditional market relationships within agriculture may be altered significantly. This implies a redistribution of income among commodity groups as well as regional shifts in production and farm income. Vegetable derivative meat and dairy analogs exemplify this type of development. Growth in crop production may take place at the expense of animal production. However, the implication for the adversely affected segments is one of direct displacement by growth of new production and distribution systems.

Displacement of conventional products by food and fiber synthetics and substitutes may be expected to proceed at varying rates, occurring first for those "soft" products that undergo major transformation through processing. "Hard" products, marketed in their near-natural form, may not be emulated so readily. But the fact that consumers increasingly demand products in processed, ready-to-eat forms means that these hard products may face increasing competition through a secondary displacement phenomenon.

Nevertheless it is not the rate or manner by which displacement will occur that is of concern here. Rather it is to recognize that alternate suppliers exist—suppliers with the capability of emulating agricultural products, developing wholly new food and fiber products, and producing these new products without regard to season or vagaries of environment, and of marketing their products through an industrialized distribution system. Experience to date with these alternative sources of food and fiber raw materials indicates that they have the capability of developing superior systems of production and delivery to which buyers shift quite freely whenever market demand forces make it feasible to do so [25]. The harsh but realistic facts are that farmers are largely in the business of producing raw material inputs for the distribution system, and as a consequence they are more vulnerable to the threat of synthetics and substitutes than anyone else involved in the production-distribution process. The atomistic structural characteristics of commercial agriculture serves to heighten this vulnerability. The threat of future displacement by this potential competition adds another dimension to the requirement for more sophisticated production and marketing operations within commercial agriculture.

The changing public view

Continuing urbanization also has special significance to commercial agriculture. The agricultural fundamentalism that traditionally provided a base of public support for farmers has been replaced by an urban fundamentalism [2]. There has been a corresponding wane in public sympathy and support for agriculture in the traditional sense. Symptoms abound that this support base will continue to diminish. Perhaps the

most dramatic of these is the recent proposal to reorganize the executive branch, which would submerge the identity of agriculture in a new cabinet structure and redistribute the existing activities of the U.S. Department of Agriculture. Another highly visible symptom is the payment-limitation provisions appended to the basic farm legislation in 1969. Significance of this development lies not in the limitation itself, which many have maintained is ineffective, but in the precedent that was set. For the first time since the inception of farm programs in the 1930's Congress moved toward less direct public support for commercial farmers. Further reduction in direct support levels will be greatly facilitated by the 1969 precedent.

A quantum shift in this direction could well take place with the implementation of the welfare reform program proposed by the President, now under consideration by Congress [21]. Adoption of the proposal to place low-income farmers under aegis of welfare legislation would give sharp public differentiation to the problems of poverty in a rural setting and those involved in producing a sustained and adequate national food and fiber supply. This differentiation would undercut the base of support for commercial agriculture. As a consequence the issues that affect commercial agriculture very likely would be shifted to a lower level on the scale of public concern [17].

However, it is unlikely commercial agriculture will be abandoned and left to its own devices as a result of shifts in public view. Instead, the national policy thrust probably will take a different direction, very likely entailing legislation to facilitate action by agriculture to manage its own affairs. Indications of this change in national policy stance are found in the recent emphasis given to bargaining enabling legislation and the flexibility imparted to several marketing order programs. As national policy moves in the facilitating direction as contrasted to direct assistance, commercial agriculture will need to exercise a degree of ingenuity and inventiveness considerably higher than that which it has brought to bear on past problems. The organizational operational framework that provides the rationale for facilitating legislative support will need to be developed by producers themselves. And this implies a significant increase in the degree of production and marketing discipline to make raw product producing sectors compatible with the industrializing distribution system. This change will not be a simple and easy task.

Endogenous Forces

It is popular to argue that production agriculture is rapidly moving toward full partnership in our industrialized economy [19, 20, 22]. This change implies larger and more complex production units in virtually all agricultural industries. It also is argued that the underlying forces of change are so persuasive that the emergence of any agricultural production system other than a closely coordinated and controlled, hence industrialized, system is highly unlikely. We concur. Evidence is ample that such change is occurring [8]. Further, we agree with Stout that the process is *revolutionary* rather than *evolutionary* and that the consequences and outcomes the change presents are beyond our conventional planning horizons and beyond the conventional tools of planners [20].

In addition to change in response to exogenous forces already mentioned, the trend toward industrialization of agricultural production is being driven by a number of internal, interconnected forces. Among the most important of these are (a) an unprecedented rate of technological advance, (b) greatly increased needs for capital and the inability to obtain financing through traditional channels, and (c) more sophisticated and knowledgeable management. We consider the latter to be the chief factor that will influence the future structure and performance of production agriculture. But the emergence of a new caliber of management is not an independent trend; rather, it is closely associated with both the rapid technological advance and rising need for capital occurring in commercial agriculture.

Technological advance

The impact of increased applications of new and improved technical inputs in substitution for conventional inputs on farm productivity, numbers, and scale of operation is well documented [7, 23]. Rapid technological advance probably has been the single most impelling force dictating the current structure of production agriculture and generating major adjustment problems. The effects of discrete changes in technology, such as the adoption of mechanical harvesting and hybrid varieties, have been studied in detail [18]. The major displacement effects on conventional agricultural inputs, chiefly land and labor, of these changes are highly visible. Equally visible has been their contribution to agricultural productivity, which has been of such magnitude that a major component of federal programs has en-

tailed attempts to control output. Less attention has been given to the more recent and continuous changes in technology that have had relatively smaller impacts individually but are significant in the aggregate. These continuous incremental improvements in the quality and situation-specificity of off-farm inputs create an onflow of new technology that heavily influences the emerging character of commercial agriculture.

The outpouring of new technology from public and private research and development sources may be expected to continue at an unprecedented rate. And because of modern communication and continuous educational efforts in both the public and private sector, the development-to-adoption time lag for this technology will continue to shorten. Continuous pressure is thus exerted in the direction of even higher productivity associated with complex, large-scale, and highly capitalized production units. Consequently management of supply would appear to be a pervading problem, especially under conditions of less direct government involvement in the affairs of commercial agriculture. This proliferation of technology also requires better management; better knowledge of alternative methods of producing and marketing agricultural products; and, perhaps most importantly, an ability and willingness by farmers to abandon conventional and comfortable methods of operation for totally new ones. The stresses on management for continuous adjustment are significant.

Rising need for capital

With the rapid substitution of capital for other inputs associated with recent technological developments, the requirement of farming units for large quantities of operating and investment capital has become critical. Moreover, traditional methods of financing agriculture are becoming increasingly inadequate as farming units grow in size and sophistication. Increases in the total amount of capital needed by farmers and increases in the size of individual farmer loans have generated agricultural financial requirements that often exceed the capabilities of conventional capital sources. In such instances farmers are forced to seek credit from other sources, including large city banks, where they must compete with nonagricultural industries for loans.

The risk to lenders is also increased as farm size increases and as individual operations often become so complex that conventional lenders lack the expertise to evaluate loan applications or to adequately service loans after they are made. A consequence of this development is that lenders are increasingly requiring advanced assurance of markets and of profitable outcome of investments before loans are made. Contracts and other forward-pricing techniques are being used to provide this assurance [22, p. 5].

Changes and new approaches within the credit system have been proposed to alleviate the mounting problem in agricultural credit [9, 6]. These are designed chiefly to improve the ability of the credit system to provide for the increasing capital needs of agriculture. However, our concern here is with the posture of the farmer himself and not the farm credit system. Regardless of the methods adopted to channel capital into agriculture, it seems clear that the farmer's ability to manage larger amounts in a complex farming situation will be severely tested.

Emerging management philosophy

Technological advance and increasing capital needs are among the major current trends in commercial agriculture. And of prime importance is the fact that they bring with them a new requirement in terms of management capabilities and management philosophy for agricultural producers. Whether or not this requirement is met, in our judgment, is the single most critical determinant of how production agriculture will perform in the emerging food and fiber system and, specifically, of performance at its interface with the industrialized distribution segment of the system. How will the successful managers of the emerging large-scale, highly complex production segment approach the problems of marketing? Can they be expected to continue their passive attachment to and decision-making role in the distribution of food and fiber products? Only those managers with superior management skills and "aggressive-expansionist management philosophies," to use Minden's term [10], are expected to succeed in the impending adjustments of production agriculture. And the expected philosophy of approaching marketing aggressively implies an anticipation that the farm managers of the future will seek and evaluate astutely all possible alternatives for more efficient and orderly methods of marketing the products under their command.

An integral part of accomplishing this task will be acquisition of management skills to operate effectively at the interface with the distribution system. We expect that much of this skill will be

imported from outside commercial agriculture. In other words, we expect farmers and farmer organizations will increasingly hire experienced and highly trained management experts who possess skills that match those in the distribution system with which they will deal.

Courses of Convergence

Forces originating both outside and within the framework of commercial agriculture are operating in the same direction. Requirements being imposed upon producers by the emerging distribution system, threats posed by synthetics and substitutes, and the loss of public support all tend to exert a "pull" effect for change in performance of the production establishment. Advances in production technology, escalating farm financial requirements, and especially the changes in managerial philosophy that these developments are bringing to farming constitute a "push" effect toward a sophistication in marketing to match the technical progress in agricultural production. The two sets of forces are on a course of a convergence in interests of producers and food and fiber distribution firms.

The climate for meshing operations of farmers and distribution firms will become more favorable in the future. Producers will intensify their search for ways of becoming an integral, in fact essential, part of the total process by which consumer demands for food and fiber supplies are met. Distribution firms will respond favorably to such producer effort. The desire for more order and certainty in the inflow of raw product supplies has provided much of the drive for past and present integrative activity on the part of these firms. While the need to manage and control product inflow is expected to increase, comparatively few distribution firms regard farming as a profit center with high potential, and there is a general aversion to integration through ownership of farm resources.

While we think that the climate for a closer linkage of farmers to the distribution system will improve, the traditional economic adversary relationship between producers and marketing firms will not entirely disappear. However, this relationship may be altered materially as producers enter into continuing arrangements with marketing firms to achieve mutually advantageous long-term goals. In such instances we anticipate that the application of power from each size will be tempered by the community of interest and that a philosophy will emerge that reflects a search for appropriate equity considering the contribution of each to the endeavor. In this search we envision continuing conflicts between producers and marketing firms and that the resolution of these conflicts will in large measure turn on the relative market power position of the two groups.

The forces we have mentioned will override the barrier of continuing conflict of interest inherent in the basic producer-distribution firm dichotomy, and the consequence is expected to be an increasing linkage of production agriculture to the distribution infrastructure. In concept the subsystems that evolve will be characterized by coordination and control through the full continuum of events starting with anticipated consumer demand and extending to the basic plant or animal production decisions to meet this demand. Considerable progress in this direction already has been achieved in some subsectors, particularly poultry, processed fruits and vegetables, and dairy products. Progress has been slow in others such as cotton, food and feed grains, and red meat animals. We anticipate that future progress will continue to be uneven, but we expect heightened effort in practically all of the major subsectors of agriculture.

Meshing Agriculture and the System

Implicit in the foregoing discussion is the fact that further aggregation on the producer side is a requirement for effective meshing of production agriculture and the distribution system. And implicit in the aggregation and meshing process is the prospect that new mechanisms will need to be developed to replace traditional exchange institutions and arrangements. Consequences of past integrative activity provide support for this contention. The accompanying decentralization has resulted in a decline in the role of central markets. Fresh and processed fruits and vegetables [15], livestock [13], and poultry [14] are commodity groups that provide readily visible examples of this phenomenon. Price discovery processes are becoming more obscure as markets decentralize and interfirm negotiations supplant traditional open market methods of exchange [12].

Use of conventional methods

Over the years and in a variety of applications producers have used state and federal market orders, bargaining associations, and cooperatives as organizational devices for aggregating their marketing efforts. These applications have involved a mixture of motivations: the desire for market

power, for efficiency in marketing operations, and for order in the marketing process. The efficacy of these approaches in dealing with the adjustment problems confronting commercial agriculture cannot be dealt with here in detail. However, general observation regarding their capabilities is appropriate because it is suggestive of the dimensions in which inventiveness is needed.

We see little hope for bargaining as an effective approach to the organizational and control problems confronting commercial agriculture as long as it remains primarily a concept of negotiating price and trade terms. In past performance bargaining associations have demonstrated limited capability to adequately govern production, either to match the requirements of the market or to avoid the self-defeating production response that has accompanied enhancement of grower prices as a result of successful bargaining effort. These shortcomings are inherent in the limited degree of organizational integrity that producers can achieve within the bargaining framework under existing enabling legislation. If producers are to effectively use bargaining as an organizational approach, the framework must be expanded to include the production and marketing discipline necessary to gear producer output to the needs of the distribution system. Legislation is currently being considered that would constitute a partial move in this direction [26]. If the legislative framework is modified to permit a broader range of cohesive effort on the part of producers, bargaining may well be transformed into a concept that has considerable potential for meshing production agriculture to the distribution system. If no change in this direction is forthcoming, bargaining will continue to have limited value for this purpose.

When used in conventional form, state and federal market orders generally exhibit the same basic limitation as the bargaining concept—inability to exercise sufficient control over production. However, we view the market order concept as a point of departure for the development of macro approaches that may be effective for meshing producers and the distribution system. To varying degrees market orders have sought to achieve orderly market flow, product uniformity, and price stability. Market orders could be transformed into more powerful tools, especially if they are used in concert with cooperatives and other types of multiproducer firms.[2] There is a need to rethink the required attributes of market orders in the context of the changing requirements of farmers and emerging configuration of the food and fiber distribution system. Closer control of marketing operations, ability to directly regulate production, and capability for rapid response to changing demand or supply conditions would appear to be areas in which the market order concept may need rather substantial revision. To appropriately transform this concept, changes in basic enabling legislation likely will be required.

Cooperatives have essentially all of the features and the flexibility of a conventional corporation. Consequently, they should be able to perform in a fashion analogous to such firms, especially those corporations that are involved in food and fiber distribution. A few have demonstrated this convincingly through the scale they have attained, the horizontal diversity of their operations, and their ability to achieve vertical integration of production and marketing processes.

On balance, however, cooperatives have not reached their full potential as a mechanism for linking production agriculture to the distribution system. More often than not, their operations encompass a narrow range of processing and marketing functions. The tendency has been to view these confined operations as a profit center and to focus upon obtaining levels of volume and efficiency that would reflect high performance in this regard. While these are appropriate procedures and objectives for cooperative firms, more will be required. They will need to devote more resources to the development of linkage to the distribution system through ownership or by other means. Lack of capital, management expertise, and perhaps vision has contributed to this shortcoming in cooperative activity. All of these constraints will need to be overcome.

We anticipate substantial increase in the use of cooperatives as a means of correlating the mutual interests of producers and firms in the distribution system. The advent of joint ventures involving cooperatives and firms positioned forward in the distribution system is an inventive and constructive move in this direction. More innovations of this type, as well as investment of

[2] Recent developments in the dairy industry illustrate what we have in mind here. Associated Milk Producers, Inc. has used the bargaining-market order-cooperative framework as a point of departure for developing a system for coordination and control of production and marketing dairy products over a 20-state region extending from Texas to Wisconsin. About 12 billion pounds of milk were involved in 1970.

cooperatives in forward marketing facilities, are required to achieve the necessary degree of producer involvement in forward marketing activities through the cooperative approach.

Alternative organizational arrangements

More astute applications of the current organizational options open to production agriculture may not be sufficient to meet the needs of the future. Entirely different organizational arrangements may well be required. The marketing board concept deserves close scrutiny, in view of its potentials for combining production-bargaining-marketing concepts into a single unit of organization [12]. Limited partnerships or closely held corporations may be another means of achieving interfirm relationships that link producers to the distribution system. Quasi-government corporations or marketing authorities are additional alternatives that need to be considered. Moreover, none of these approaches may be adequate for the meshing process. The requirement may well entail concepts of organization within agriculture and for relating agriculture to the distribution system that are yet to be envisioned.

Conclusion

The situation depicted here has numerous specific implications to producers and agricultural economists. Either directly or through inference many of these have been identified in the previous discussion. However, there are a few broad implications that deserve further comment.

From the standpoint of the producer two major requirements seem to emerge. First is the requirement for a trade-off of part of their individual decision prerogatives to attain the level of aggregation needed for an appropriate interface with firms in the food and fiber distribution system. This is a major decision that most producers make reluctantly. Moreover, it is not a decision of dichotomy but one of degree. There is generally an inverse relationship between the level of decision prerogative retained by individual producers and the effectiveness of their aggregate efforts. Hence both the losses and benefits to individual farmers involved in alternative organizational forms need to be weighed carefully. Much more intensive educational effort will be required to provide producers with the information base they need to make this decision intelligently.

A second and closely related requirement bearing on the producer is that for the development of organizational and operational schemes of aggregation that are efficient in function and that will allow farmers to become participants in the emerging system with appropriate equity in the proceeds derived from the final marketplace. This constitutes a substantial future burden for the producer and gives rise to a change in the role and responsibility of agricultural economists that is of major proportions. We examine these changes briefly.

The enclosure process under way will require substantial modification in the traditional analytical approaches employed by agricultural economists. The analytical requirement emerging is one that can deal effectively with problems involving multifirm and multifunctional segments of the system. This is in sharp contrast to the conventional analytical framework of the individual firm and much of the marketing and price analysis that has been conducted. The relevant center of inquiry will be horizontal or vertical zones of activity involving interrelated agribusiness firms.

In some cases these zones may be quite narrow, but the general tendency over time will be for them to become broader and more encompassing. Clearly the cast of the analysis in the future must transcend the production economics-marketing barrier that is largely of internal professional construction but has considerably influenced our past analytical approaches. The systems-oriented approach that will be needed in the future has been given much lip service by agricultural economists. Progress in this direction, however, has been with glacial slowness. The pace must quicken if we are to develop the expertise needed to deal with the relevant food and fiber problems of the future.

Basic in our public value system is the concept of atomistic competition as an appropriate framework for economic activity. The consolidation and linkage occurring throughout the food and fiber system produces a structure that runs counter to this framework. Hence, public interest issues will become an increasing responsibility of agricultural economists in the years ahead. The fact that competition will be between groups of firms that are larger and operationally interrelated will give rise to a welter of questions requiring continuous evaluation of conduct and performance. Providing adequate answers under the emerging structural arrangement will call for a substantial increase in analytical sophistication. New theoretical criteria for evaluation also may be needed. The demands on agricultural

economists generated by the structural change will be further fueled by the increasing consumer interest orientation that is gaining prominence in the political arena.

Our final comment pertains to the level and extent to which agricultural research and extension economists in the public sector should become involved in effecting change in the food and fiber system. We do not see their role as a passive one. Generalized advice, often involving only an enumeration of alternatives, simply will not be sufficient. Active and positive participation is required if the profession is to fully meet its responsibility for an efficient and viable food and fiber distribution system. Those who seek the assistance of the agricultural economist not only need to know what the data indicate but also what economists think is the appropriate solution for the problem at hand. Intelligent advocacy, but not evangelism, must replace the role of neutrality that the agricultural economists have traditionally occupied. This involves not only an adjustment in the philosophy of most researchers in agricultural economics but also a substantial change in that of the institutions and agencies at which they work and of the administrators who guide their activities. This change will not come easily, but it will be required if agricultural economists are to discharge the special trust and responsibility that have been given them.

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Discussion: CHARLES E. FRENCH, Purdue University*

I am disappointed with the paper. Such capable authors were expected to handle at least a reduced version of the problem with rigor. The paper is too much like many of mine—it paints with too large a brush.

My major concern rests within the following set of factors. This is a society of organizations. To be effective in our commercial world, individuals must succumb in part to organizations. The alignment and changing nature of these countervailing organizations as portrayed by the authors put the farmer in a most vulnerable position. He would need to build for himself organizations with effective countervailing power. Yet the hope of the authors is predicated on some weak, improved meshing at the interface with distribution industries. Farmers would depend considerably upon buying their organizational expertise from their adversaries. Farmers, it is hoped, will be saved by cooperatives, but there is little new to encourage us along those lines. Any real optimism for farmers must come from doubting the authors' forecast of environment or in seeing some new organizations not proposed. They leave me with agriculture in a great dilemma. Possibly they are right. If so they are making a profound prediction of dire consequences for this major industry.

A contention is made that linkage between farmers and distributors will come more by vertical than by horizontal integration. Proof? Contention is that coordination will result in more price stability for raw material. Proof? In fact broilers probably show just the opposite. Contention is that producers must acquire greater sophistication in negotiation under coordination. Proof? Signing a contract is not a very sophisticated event for broiler producers!

Changing public view is thought to be ready for sweeping "legislation to facilitate action by agriculture to manage its own affairs." Our government of checks and balances has always withstood this rather well.

Inference is that the public proposed cabinet reorganization to downgrade the U.S.D.A. A bit of an overstatement? Payment limitations were philosophically a blow for some farmers, but were these such a drastic downgrading of public support for agriculture? Inference is that welfare support should still be used to shroud commercial agricultural payments. At best this is a bit old-fashioned.

"Conclusions" were that we would have a trade-off of loss in producer individuality with aggregated strength so terms would be better for meshing at the interface. Institutional innovation would evolve. These ideas were the preamble to the paper, not the conclusions. The conclusions should have shed some light on such questions as:

(1) Is there hope for the traditional farmer in these evolving systems? Is the farmer as a manager viable? Is the broiler thing an example or an aberration?

(2) Will these systems allow individual farmer decisions when we have an aggregate oversupply of 6 to 10 percent, as has prevailed for the last two decades?

(3) Will food organizations interspersed in a conglomerate industry protect the farm interests as well as the old-line food companies did?

(4) Is any value left in the public sanctions and privileges historically accorded to agriculture? Will the thrill of new bedfellows for farmers be worth the wrath at home!

(5) Will the American producer get anything from these emerging systems to protect his necessary overseas markets?

(6) If the cooperative cannot handle this new job, what then?

(7) What do the emerging systems mean for consumers?

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* Comments are mine, but helpful suggestions were given by Paul L. Farris, Emerson M. Babb, and Wilfred V. Candler.

Discussion: MILTON L. MANUEL, Kansas State University

The authors have made a significant contribution by viewing agriculture in its broadest sense, in an agribusiness perspective. They are to be commended for dealing with broad major issues and for sketching an overall framework.

Godwin and Jones see increasing linkage of production agriculture to the distribution infrastructure in the period ahead. They foresee that greater linkage being accomplished in two ways: (1) by individual firms with sufficiently large operations and adequately integrated to cover the span of operations from the basic producer to the ultimate consumer; (2) by using more and more sophisticated interfirm arrangements to provide greater overall coordination of all activities involved from producer to consumer—a conclusion that seems to be both realistic and constructive.

Our chairman asked me to comment on implications that views expressed in the paper might have for the grain portion of agriculture. I shall do this by making a few brief comments on the wheat sector.

The question that is germane, as I see it, is: "To what extent will there be greater linkage between the production and the processing-distribution parts of the total wheat system in the period ahead?" Answers might be approached by examining the two alternatives Godwin and Jones gave.

Let us look first at the large-scale integrated firm approach. "To what extent does it appear that wheat will be produced by individual firms that are integrated from production through retail distribution of food products made from wheat?" I view this as a very extreme form of coordination and one that is not likely to take place to any significant degree in the foreseeable future. Don Paarlberg has identified several conditions needed before "large-scale integrated units" would be feasible [2, pp. 113–115]. The economic activity of producing wheat falls far short of meeting Paarlberg's conditions.

I see greater possibilities for the second alternative: increase coordination via more interfirm arrangements. Ray Goldberg's study of agribusiness coordination documents considerable coordination already in the wheat system [1, pp. 27–99]. I feel we can expect more and tighter coordination between all stages of the wheat system in the future. There are some indications that farmer cooperatives will play a greater role in this development. Larger and more diversified regional grain cooperatives have emerged as a result of consolidations. Many have increased processing activities. New activity in the export market has been particularily noticeable. How much further farmer-owned cooperatives will go in providing tighter coordination remains a serious question.

The matter of producer aggregation is especially crucial. I think it is quite likely that we shall see more experimentation in bargaining, market board type of activity as a means of developing more wheat-producer aggregation in the future.

One conclusion reached by the authors seems questionable. They stated that agricultural economists should see their role as being ready and willing to state what they feel is the appropriate solution. A chief difficulty is that stated solutions often imply a course of political action that may help some while hurting others. Such a situation would place any public employee in a questionable position.

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Farmers' Options

CHAIRMAN: JAMES G. YOUDE, OREGON STATE UNIVERSITY

Discussion: KENNETH R. FARRELL, Economic Research Service, USDA

Godwin and Jones see very limited possibilities for bargaining and only slightly better prospects for marketing orders as effective approaches to what they perceive as the organizational and control problems confronting commercial agriculture. They opt for legislative changes to provide more effective production and market control.

I concur with Godwin and Jones that orders and bargaining programs as currently authorized contain congenital weaknesses that preclude rigorous, restrictive management of supply in most commodity sectors of U.S. agriculture. The inability of farmers to organize and discipline themselves voluntarily on a marketwide basis precludes monopolistic application of either device in commodity markets involving large numbers of producers in geographically and economically diverse areas of the country. Even in the case of specialty crops the inability of the order or bargaining group to regulate entry and control production, possible demand substitution among commodities, and potential competition from imported products constrains substantially the exercise of monopolistic power under the programs.

Direct price enhancement by managing supplies may be for some the principal goal of group action. But terms of sale such as credit, delivery schedules, quality standards, shrinkage allowances, bonuses, etc., have a value and affect net returns to producers. A bargaining association with a sufficiently large market share may be able to arrange or negotiate more favorable terms than could the individual member of the group. A marketing order may be used to enforce minimum quality standards to the aggregate betterment of both sellers and buyers. Regularizing flow of product to market, arranging and standardizing contracts for future deliveries are other functions which might be influenced through group action. Many possibilities exist for developing improved coordination in marketing farm products and inputs—possibilities which some cooperative marketing, purchasing, and bargaining associations have been slow to recognize and capitalize upon.

Godwin and Jones argue that if producers do not now have the power to substantially improve farm prices and incomes through group action, legislation should be enacted to strengthen their abilities to do so. Some strengthening of legislation may be in order, legislation to discourage discrimination against producers who wish to undertake group action—extension of marketing order authority to all agricultural commodities, for example. Some have argued for creation of marketing boards of the European and Canadian type to provide strong market power to producers. Some have proposed a "Wagner type" bargaining bill for agriculture; some have proposed to transfer to farm groups the essence of authority now contained in federal price programs. My own preference is to move toward equation of agricultural market power at a lower rather than higher degree of concentration in our economy.

But even within the prevailing legal-institutional environment of agricultural markets, I believe there are opportunities for more extensive and effective use of group actions to improve market coordination and alter nonprice terms of sale in several sectors of agriculture. These opportunities vary widely and should be examined pragmatically and with realism. For agriculture as a whole the gains in income are likely to be modest but not insignificant.

Discussion: RICHARD W. SCHERMERHORN, University of Idaho

I WOULD suggest that integrated corporations will become a dominant factor in the future of agriculture because they provide the method by which many of the problems and implications arising from our emerging food and fiber system will be solved.

There are many implications arising from our emerging food and fiber system, but I shall suggest three that I believe have the most bearing on the integrated corporation activity in agriculture: (1) a trend toward a market-oriented agriculture that requires an increased degree of coordination and control throughout the entire agribusiness system, starting with antici-

pated consumer demand and extending to basic production decisions; (2) a trend toward an industrialized agriculture, caused by technological advance, which is creating a highly capitalized agribusiness system in the face of increasing difficulty in acquiring capital from traditional sources; and (3) a real need, because of the trends, for increasing management capabilities and for changing the management philosophy of many agricultural producers.

Let us look at each implication in terms of resulting needs that must be fulfilled by agriculture in the future and how the integrated corporation may be one way, perhaps the way, of fulfilling these needs.

There is a definite need to better coordinate production and marketing to obtain quality control and/or closer coordination of product flows. Where this coordination is not readily achieved through prevailing market mechanisms, it will be achieved by either contracts or ownership. And if farmers make it difficult to negotiate price and terms of contract, it seems logical to expect food companies to integrate backward into farming. An additional benefit can be gained by this move: the firm will know exact costs of production and will be able to more effectively forward contract with its buyers.

The magnitude of capital requirements in agriculture, resulting from rising prices, specialization, increasing farm size and more rapid capital turnover due to technological obsolescence, must somehow be met. Today financing from earnings or through traditional sources of credit is not adequate. The "public" integrated corporation is one method of obtaining capital through stock issues and/or sale of bonds; and this method taps capital accumulations outside of agriculture.

There also exists a need to increase management capabilities within agriculture. The integrated corporation is generally in the position to employ highly specialized management personnel, particularly personnel with the functional business skills generally lacking in most farming operations. Integrated corporations can secure such personnel because they usually have more management development possibilities within the firm and are in the position to offer management personnel more fringe benefits such as profit-sharing and stock option plans.

In summary, integrated corporations will play a dominant role in the future of agriculture because they offer solutions to the needs of the industry. Integrated corporations can provide for better coordination between production and marketing; they can secure adequate capital; and they can secure the highly qualified, specialized management personnel required within agriculture today.

Discussion: Joseph H. Marshall, Gold Kist, Inc.

One's view of the emerging food and fiber system is influenced substantially by one's background. The fiercely independent midwestern grain farmer, no doubt, will have a different view of the future of agriculture from the small undercapitalized southern farmer. The large corporate farmer of the west will have a view that will be quite different from the small northeastern farmer. Those of us representing agriculture from different areas here today will no doubt reflect the sentiments of those areas.

So that you will know my biases from the start, I have spent eight years with a southern farmer cooperative successfully engaged in contract production with our members for broilers, eggs, and pork; and we also have experimental operations with other commodities. With this background, we have been able to view the vertical integration or systems concept of agriculture in operation and to see its disadvantages as well as its advantages.

My remarks are directed toward cooperatives' roles in meeting these changing conditions. To make a set of priorities on all farmers' challenges of the future can be rather presumptuous, but from my point of view the primary challenges will be for an improved marketing (distribution) system and additional capital for both production and marketing requirements. An ever-expanding inventive management philosophy is necessary and assumed. The management requirements for the marketing and distributing demands will require not only increasing management skills from the agricultural sector but an increasing input from what is normally considered the industrial or nonagricultural sector. For example, for farmers to perform more of the total marketing function for their products on a cooperative basis, both nonfarm management skills and nonfarm capital will be required.

The market environment is one that generally offers greater returns on investment for firms

with established brand names. Likewise, these firms with an established brand franchise with consumers have a preferred position within the marketing channel. With the ever-increasing competition for shelf space in the supermarket, it has been said that the average supermarket will allow perhaps three national brands in addition to private labels and local labels. The capital and managerial requirements for establishing a broad national brand franchise are staggering and considerably more than most organizations could support alone.

The cooperative alternative for meeting the challenges of the food system of the future will of necessity involve joint regional cooperative activity. It is highly unlikely that a local or regional cooperative can establish a national brand for major food items, as Land O' Lakes and Ocean Spray have done for single items in earlier years. Capital requirements and competitors' pressures are the main obstacles.

A successful national food marketing cooperative organization will of necessity involve transferring the marketing decisions from the regional processing cooperatives to the national marketing cooperative. This could be the greatest obstacle to cooperatives achieving a consumer brand franchise comparable to those of some of the well-known national food marketing corporations.

It may be obvious to some that capital requirements have not been given a major position in this discussion. This has not been done to minimize the capital factor, because it is great and major. However, the greatest problem in organizing the most effective cooperative approach to the emerging and continuing forces in the food system is that of combining the resources of cooperatives in a workable and productive organizational unit.

Implications for Research

CHAIRMAN: R. E. BRANSON, TEXAS A&M UNIVERSITY

Discussion: WILLARD F. MUELLER, University of Wisconsin

ALTHOUGH all economists do not agree as to the nature and causes of the failures of marketing research in the 1960's there now are important areas of consensus. One of these is with respect to the *organization* of our research efforts. Another is the conviction that more research should be directed at real world problems. The two criticisms are not unrelated: our failure to organize research properly may prevent us from tackling certain really important problems.

The research effort of the National Commission on Food Marketing suggests the potential advantages of large-scale, integrated research efforts. This is not to imply that the National Commission realized its full potential; but despite shortcomings, this experience illustrates the value of concentrating substantial resources and a critical mass of expertise in tackling a significan problem. Serious consideration should therefore be given to a recent proposal for creating a consortium-type arrangement for conducting regional research in the North Central states.

The paper further argues that priority be given to research that analyzes the impact of technological and organizational change on economic, social, and political institutions. This requires research relevant to *public* rather than *private* decision-making. The payoff to society from research helpful to public decision-makers increasingly exceeds that from research aimed solely at helping private decision-makers. Applied research in such traditional areas as plant efficiency studies to aid private decision-makers may have high benefit-cost ratios; but as marketing firms grow in size such studies should increasingly be financed by private firms benefiting from them.

Discussion: R. E. SELTZER, Dunlap and Associates, Inc.

Effective market research must be done by private consultants for their survival; however, making market research effective generally becomes the client's responsibility. Private consultants have advantages in market research: they can deal with the real problem, thus effecting the needs that the client must entrust to the consultant's decision. Having direct contact with the client management and staff is very important toward understanding of final recommendations involving decisions for implementation.

Methods of reporting results of a study may vary according to the size and nature of the company. Follow-up implementation is not generally part of the consultant's job. This is unfortunate because it leaves the consultant open to the many implementation mistakes. The consultant is the "scapegoat" if the program fails.

Specific studies in various fields of market research are briefly discussed: (1) a study in Jordan dealing with the ceramics, glass, and building materials industries; (2) a study for a major oil company to determine farm supplies demands and distribution problems; (3) a study for a feed mill to determine their needs toward either remodeling an old plant or relocation for a new one; (4) a study for a fertilizer company with new forms of liquid and granular fertilizer to determine the most appropriate location as to acceptance, demand, and potential use of their product; and (5) a study on market-entry feasibility for a new vegetable processing plant.

These examples are only a few of the types of studies in which the private market research organization has been involved. However, they serve to illustrate the point that market research in the private sector is principally concerned with assisting management and policy-makers in arriving at sound decisions. Provided that the work is accurate and that the recommendations are realistic, possible of implementation, and acceptable to the client, then from the standpoint of the consultant his market research is effective.

Discussion: W. D. EICKOFF, Ralston Purina Company

There are three areas that I believe should be rated as priority marketing research needs in the 70's. Research in these areas should increase returns to all facets of agribusiness and therefore yield a high return on investment. These areas are:

1. Analyze agribusiness, the focal point being our markets for red meats, poultry, and milk. At present we have adequate information about what consumers buy but limited knowledge of why purchases are made. In the past most research in consumer behavior has emphasized packaged and nonperishable items and has excluded red meats, poultry, and milk.

2. Analyze future export markets for cereal grains, feed grains, and soybeans, with the assumptions that the following events will occur: (1) entrance of England into the Common Market, (2) increased self-sufficiency of grain production in selected countries of South America and South Asia, and (3) increased significance of Eastern European countries as net importers.

3. Develop procedures to provide additional and more reliable market information. At present many transactions of raw and partially processed food and feed products are made with limited knowledge about industry stocks and movements. This partial void exists at all stages of the marketing channel, including retail, wholesale, processing, and farm levels.

To conduct research in these three areas would require reorientation at many land-grant universities. Suggested reorientation would include the following changes:

1. Adopt a marketing-oriented approach in research programs.

2. Put a moratorium on model building and divert resources to improving marketing information.

3. View changes in agribusiness as opportunities to improve performance rather than as problems.

4. View research as a vehicle to assist in decision-making.

5. Analyze the market for research conducted by agricultural economists. Is the market agribusinesses and related institutions, or is it fellow agricultural economists?

Discussion: THOMAS L. SPORLEDER AND JOHN P. NICHOLS, Texas A&M University

Increasing industrialization of food and fiber processing and distribution firms is evident. In simultaneity with these changes in the processing and distribution sectors, it is well documented that production units are dwindling in number and increasing in size. These changes have implications for the morphology of land-grant university agricultural marketing research.

One consequence of industrialization is increasing complexity and interdependency within and among agribusiness firms, which permeates all levels, from production units through the marketing channel for agricultural products. New problems, alternatives, and opportunities arise, many never before faced by the decision-makers responsible for their resolution. Opportunity cost on invested capital in larger and more complex firms places a premium on market want cognition as never before.

One of the most basic needs of agribusiness units is simply for accurate, unbiased information that can be utilized as a base for intelligent decision-making. However, to be of value to the decision-making unit, marketing research information must be available in a short time period.

Another consequence of industrialization is that it fosters decision-making units possessing the ability to effectuate unitary action with respect to marketing research findings. Since more such decision-making units are likely to exist in the future and since each decision will likely be more complex, the need for problem-solving marketing research will increase.

For land-grant universities to relate to these marketing needs, structural reorientation within the university may be necessary. Even though individual researchers in universities have customarily been involved with their own individual research projects, the need for multidisciplinary approaches to marketing problems and expanded problem-solving research suggests that this custom is antiquated. Research teams or task forces are more logical working units for such involvement. Indeed, multidisciplinary research, by definition, must be done by a task force. This means more "directed" research and a loss of some cus-

tomary freedom by the individual researcher. This loss of freedom is a primary reason that change has been slow.

To facilitate the response of a university to contemporary market research needs, a program based upon the ability to do problem-solving, multidisciplinary, short-term research was developed at Texas A&M University—The Texas Agricultural Market Research and Development Center. The multidisciplinary nature of the Center is an important capability when addressing the market research problems of dynamic agriculture. Creation of the appropriate task force to deal with particular problems often requires input from disciplines other than agricultural economics. Formation of this task force is facilitated by a center that can operate across departmental lines and draw upon the resources of both research and extension personnel in an orderly, continuing fashion.

The need for problem-solving research and multidisciplinary research in marketing by land-grant universities is evident as never before. With this need will come greater involvement by agricultural economists in serving various agricultural organizations. Not all land-grant universities will find it desirable to have an organization such as the Center. While much will be dependent on the agricultural base of the particular state, experimentation in research organization within land-grant universities will continue.

Discussion: ELMER R. KIEHL, University of Missouri

Agricultural experiment station administrators in recent years have been concerned with a paucity of good regional research proposals in marketing. Some proposals did not seem to attack significant problems and others were restricted to the "marketing aspects" of much broader and more significant problems. The administrative definitions of marketing and legislative guidelines may have contributed to this problem.

A new approach to the organization and administration of research in agricultural economics and sociology was recently established by the North Central regional directors. They followed the recommendations of a researcher-administrator task force. This group sought a restructuring of research so that it might respond better to the special challenges inherent in the fundamental technical, organizational, and structural changes occurring in agriculture. They recommended the replacement of all NCA and NCR committees by three broad groups known as NCRS, or research strategy committees. The three presently organized are NCRS-1, Commercial Agriculture; NCRS-2, Natural Resources Development; and NCRS-3, Community and Human Resource Development. It is hoped that such groups can mount an effective, multidisciplinary attack on very significant policy issues. Perhaps their examples can broaden the research within the various states.

The lack of access to needed industry data will be a significant barrier to such policy-oriented marketing research. It may be essential for Congress to authorize mandatory access to such information on a periodic basis. This is one of the lessons of the National Food Marketing Commission.

Contributed Papers
(Abstracts)

CHAIRMAN: WILLIAM SCOFIELD, ECONOMIC RESEARCH SERVICE, USDA

Alternative Structural Approaches to Farm Bargaining: A Cooperative Systems Model

RANDALL E. TORGERSON, University of Missouri

STRUCTURAL considerations of organization for bargaining are among the key, yet least understood, determinants of successful negotiating efforts. As structural change in the economic organization of American agriculture points to the prevalence of large-scale voluntary organizations, the structural attributes of various organizational forms and organizational interrelationships become of increasing importance. Basic questions arise about relationships of producer members to their organizations and about the interaction of various organization forms in pursuit of income maximization on behalf of farm operators. At issue is whether these large-scale organizations can provide collective goods to members and whether members are the ultimate recipients of the benefits of group-oriented behavior in these organizations.

Farm bargaining, the direct confrontation and interaction of pressure groups and firms (or government) in the determination of prices and other terms of trade, has become the focal point of contemporary farmer movements in the 1960's and is destined to become a working part of farm marketing in the 1970's. Agricultural pressure groups involved in the process of bargaining include cooperative business organizations and professional associations (individual and general farm) that are both single and cross-commodity in nature. Debate over the attributes of the centralized versus federated form of cooperative organizations has been renewed recently in the dairy industry with the evolution of multimarket combines. Spokesmen for the dairy industry conclude that the centralized organization form (with direct membership in the regional or national organization) is most appropriate for bargaining.

Structural issues among general farm organizations were not a concern so long as government programs were a major determinant of farm income levels. The federated county-state-national structure was uniquely adapted to lobbying activities with administrative and legislative bodies. With deemphasis of government farm programs and rise in popularity of collective bargaining, professional associations such as the National Farmers' Union, National Grange, and American Farm Bureau Federation have undertaken a reappraisal of their organizational dilemma. To date only the AFBF has initiated structural change, and then only through a parallel federated structure—the AAMA—that remains cumbersome for bargaining purposes. Only the NFO, organized explicitly for bargaining as a direct membership organization, has maintained strong local units of organization while adapting itself to broad marketing areas and specifically limiting the role and power of the state organization. Invariably these large professional associations, like regional marketing cooperatives, promote themselves as the farmer's one-stop solution to his marketing problems. This single- rather than multiple-organization approach to bargaining leads each to differentiate its organizational product at the expense of others.

Recent developments in organization theory shed new light on organizational structure for bargaining. Olson's theory on participation as related to organizational size and structure [6] and Cyert and March's coalition theory [2], combined with older investigations by Hibbard [4] Liefmann [5] and Emelianoff [3], suggest a multiple-organization or "cooperative systems" approach to farm bargaining. Underlying this unique representation structure is the multidimensional function of the farm operator (manager, laborer, investor, and land owner) in representing the economic interests of his farm firm *and* the fact that in agriculture (unlike labor) we are dealing with commodities that can be physically separated from their producers. These factors provide the basis for a division of labor and specialization of organizational tasks that can be used to specify structural and functional differences between basic organization types. The basic organization forms are viewed as complementary, each having its functional role in represent-

ing the farm operator's economic interests. Linkages between organizations provide farm operators with their full potential for adequate representation at the bargaining table and for the exercise of market power.

Various ways in which these organizations relate to each other and together relate to the opposite negotiating party or parties are key issues that must be resolved by farm pressure groups and worked out in pending bargaining legislation that will define an institutional arrangement for bargaining and provide for an accreditation process for identifying bargaining agents.

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The Evolution of Vertical Coordination in Agriculture: A Pork Industry Example*

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ONE key organizational development in U.S. agriculture has been a change in the system of vertical coordination of production and distribution. The move away from "spot" market coordination of various functions to contractual arrangements or vertical integration has been quite pronounced in many industries and has given rise to several policy issues. This paper presents the results and subjective analysis of the status of new vertical coordination arrangements in the pork industry from an informal survey of feed manufacturers, hog producers, packers, retailers, and others.

While firms tend to be classified into industry groups (packers, retailers, etc.) according to the activity for which they are primarily known, many participate in more than one stage of the pork production-marketing system. Interest in new vertically coordinated systems varies widely, however.

Retailers were generally not interested in new vertical coordination arrangements at this time. Pork is only one of many products and past attempts at developing quality pork programs have not been very successful. They claimed packers are often unable to meet quality specifications. Retailers preferred buying and pricing on a week-to-week basis to long-term contracts. Most retailers and packers felt that centralized cutting and packaging of fresh meat products would expand in some areas. Quality pork programs using brand identification would then be more feasible.

Some packers were found to be very aggressive in developing new vertical coordination arrangements while others were trying new ideas only on a pilot scale. The problems packers seem to be trying to overcome with new arrangements are (1) marketing variations in the hog industry and (2) low plant utilization in specific areas. Many packers are involved with either hog procurement contracts or production contracts, the latter almost always on a small scale.

Hog producers raising 15,000 to 100,000 head were interviewed, since success with this size of operation might be conducive to future vertical integration. Most of these ventures are quite new and relatively untested. They use labor or management specialization and decentralization of production to overcome management and disease problems. A few are integrated into slaughtering and processing; others expect some market advantage because of their size.

Feed manufacturers as a group are involved to the largest extent in new linkages and activities outside their industry. They are looking for expanded business opportunity that will utilize their basic resources and expertise. Increasing numbers of feed manufacturers are involved in sow leasing and production contracts and encourage their franchised dealers to participate in acquiring captive outlets for feed. Many are interested in discovering a working prototype of a large-scale production unit. A few are marketing live hogs on a contract basis.

Several different systems of coordinating production seem to be evolving slowly: (1) production under contract or closely coordinated by an outside industry; (2) production under independent control which is coordinated with the slaughtering-processing stage via marketing contracts; and (3) complete financial integration of large-scale production with either packing-processing, feed manufacturing, or both.

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An Integrated Cotton Marketing System*

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This paper examines a conceptual framework for an integrated cotton processing and marketing system. Emphasis is placed on ideas that carry major implications for adjustments within the cotton industry in the years ahead: central ginning, blending, and forward contracting.

The physical flow from farm to gin may include baling seed cotton in the field, hauling to a central site, weighing, sampling, moisture tests, and then storage in now under-utilized lint warehouses. When sufficient buy orders are received and when contract delivery dates are due, cotton will be removed from the warehouses in specified quantities and qualities, blended, and then ginned. Central gins will be equipped with high-density or universal density presses which will eliminate costly recompression of most bales.

Central ginning and blending concepts alone would likely encourage integration. In some areas of the cotton belt increased storage space would be needed for seed cotton by central gins but less space would be required by merchants for storing baled lint. This would encourage the integration of compresses and warehouses with central gins. Closer linkage between gins and merchants would seem to combine ability to develop blends with knowledge of requirements of various cotton mills.

Increased use of central ginning, blending, and forward contracting will probably induce structural changes within the cotton industry. One or a combination of at least five alternative arrangements might evolve: growers may organize into bargaining associations; mills may integrate backward into farming; farmer cooperatives may integrate forward from the farmer to the mill; joint ventures may develop between marketing firms and textile mills integrated from the farmer to the mill; or producers may enter the textile manufacturing and marketing.

Economic, political, and social developments from both within and without the industry provide the forces under which a new cotton marketing system will emerge. Seemingly radical and penetrating changes in market arrangements at each step from farm to mill will be required. Growers, ginners, merchants, mill buyers, and others may well lose some of their industry individualism. Revamped storage practices, assembly techniques, sampling practices, grade standards, and quality evaluation are necessary. Changes will be made in research orientation of industry groups, universities, and government. It will take dedicated research effort and astute experimental programs to align these opportunities into a working arrangement.

* The author wishes to acknowledge the helpful suggestions and criticisms of Marshall R. Godwin.

Financing a Changing Agriculture*

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OUTSTANDING farm debt has increased over five times since 1950 and more than doubled between 1960 and 1970 [1]. Whether the present financial institutions can provide the $60 billion increase (double the 1970 debt) expected by 1980 depends upon their adaptability to changing conditions. The distribution of the debt is changing. Commercial banks' and insurance companies' shares of the market are declining. Federal land banks' and production credit associations' shares are increasing. Noninstitutional lending is increasing rapidly. Is this increase due to an inadequate supply of institutional funds or to nonsupply elements such as tax advantages on land sales contracts and sales aids for merchants?

Both the commercial banking system and the Farm Credit Administration have recognized a need for changes in the financial institutions serving agriculture. Federal Reserve System studies suggest a need for a network of unified markets to permit small banks to market farm and other notes and to use the discount mechanism as a source of funds during peak lending periods. The proposed 1971 Farm Credit Act would remove some restrictions on farm real estate lending and permit federal land banks to make nonfarm housing loans. Production credit associations would be permitted to make loans to farm-related businesses providing services to farmers. The Farmers Home Administration has increased or proposes to increase its lending limits and broaden the sale of insured notes. Insurance companies have alternative investments to farm mortgages. The serious question for the farm sector is whether they will adapt to changing financial conditions and continue farm mortgage lending.

Some problem areas appear on the horizon. Farm Credit agencies may encounter problems in the money markets if government agencies continue to increase the use of these markets for their source of funds. Commercial banks need to find a new source of funds to meet the changing needs of agriculture. Increased use of land sales contracts also could present problems. A market for this paper does not exist. In addition, safeguards to protect buyers equity in contracts in recessionary times appear to be needed. Financial institutions such as banks and the Farm Credit agencies are moving more and more into service areas such as record keeping and trust advisory services. Movement into these areas may deemphasize lending activities.

As farms grow larger the opportunities for financing through nontraditional arrangements are increasing. Incorporation and sales of stock, sale of limited partnerships, equity financing by banks and insurance companies, and financing through the marketing agency such as the farmer's marketing cooperative are some possibilities. Enterprising entrepreneurs are finding these noninstitutional sources; unless institutional lenders remain aggressive they may lose some of their most profitable agricultural business.

* The ideas and statements in this paper are the author's and do not reflect the policy of the U. S. Department of Agriculture. Helpful suggestions were made by Lawrence A. Jones and Kenneth R. Krause.

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COMMUNITY AND HUMAN RESOURCE DEVELOPMENT

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Community Resource and Human Development

EBER ELDRIDGE

THE feeling that communities, both large and small, need some kind of special assistance is certainly not new. Community resource and human development probably is needed more in metro areas than any other place in our society. My experience and my interests have been focused on the nonmetropolitan areas of the United States; therefore this paper will be so directed. I have had the opportunity to observe and study the techniques and effectiveness of many attempts in community resource and human development. I shall attempt to explain the content of the program, discuss some of the past and the present problems, and make some suggestions for future needs.

Almost everyone associated with community resource and human development winces as he is frequently asked, "What is it?" I prepared a paper recently on research needs in rural development [4], in which I took an evasive approach by emphasizing how new research money should be used. The most frequent criticism I received was for the failure to explain the composition of a community resource and human development program. I was specifically requested to address my comments to this question in this paper.

Webster's accepted method of defining a word or a term is to examine and record the usages of that word or term. It is not the function of a dictionary to invent or innovate brilliant new definitions—merely to record the customary and accepted usages. I have decided to take that approach in dealing with community resource and human development. I plan to offer an explanation of community resource and human development based on the various programs presented under that name (or some similar name) by various institutions, agencies, and organizations. I shall attempt to fit these usages into a definition and to examine the degree to which they are competitive, conflicting, or complementary. Time and space do not permit treating each individual institution, organization, or agency; I shall therefore group the programs I have observed into classes of development activities. It becomes obvious that defining community resource and human development is not as simple as defining a word. A short precise definition is impossible because the composition consists of a complex set of interrelationships.

History

Although individual institutions, organizations, and agencies might have had their own programs before this date, the first public endorsement of community resource and human development is found in House Document 149, 84th Congress, 1st Session, April 27, 1955. This report recommended:

> Special funds should be provided to set up during the next year or so, technical assistance and extension programs in sufficient number of counties . . .

It also says:

> Over the longer term additional county and community development committees should be organized in all areas . . . These committees should include not only farmers but also representatives of public and private credit agencies, local businesses, employment services, and private credit agencies, local businesses, employment services, conservation agencies, and extension, vocational and other educational services. Such committees could help develop local action . . .

The 1960 rural development program handbook listed these objectives:

> The rural development program which was inaugurated in 1957 has three major aims: (1) to expand industry and widen the range of all farm jobs in areas with many small and low production farms; (2) to help families having the desire and ability to stay in farming gain necessary land, tools, and skills; (3) to help younger rural people obtain adequate education and especially improve job skills.

In 1961 Orville L. Freeman, Secretary of Agriculture, said,

> The department is mobilizing all its resources to

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assist state and local leaders in a vigorous program of rural areas development. This program is a major department activity and will receive priority attention of the USDA offices and agencies. The goals of this program are to create a new climate of hope and progress in each area to abolish rural poverty, to help bring agriculture, industry, forestry and other possibilities together into the most productive balance to make democracy continue to work [5, p. 195].

About the same time another federal agency became interested in nonmetropolitan problems. The Area Redevelopment Act was signed by President Kennedy in May 1961, to be administered by the Area Redevelopment Administration in the U. S. Department of Commerce. The aim of the area redevelopment program was to supplement local initiative and capital in financing additional employment opportunities in areas of the most severe unemployment and low incomes.

Other agencies have had programs aimed at low incomes, unemployment, and the development of the rural community. The community action programs of the OEO were some of the more widely publicized. The Nixon administration has returned to the older title and called for "rural development programs." The proposed bill, S1612, initiated April 21, 1971, is designed to establish a revenue-sharing program for rural development.

An Objective Function

My examination of numerous programs in the general area of community resource and human development leads me to this conclusion. A common objective exists on a very broad, general level—a hope to improve the quality of living of people. Community resource and human development programs can be judged successful only when there has been a positive change in the living quality of people when comparing time period T_1 with time period T_2. Development is the process by which the positive change is achieved. I view quality of living as living satisfactions, the level of which has been improved in the past and can be improved in the future. The aggregation of individual satisfactions then adds up to a satisfaction level for the community, which is synonymous with living quality. If I had the ability to conceptualize and articulate, I would describe the necessary components as justice, security, equity, growth, stability, etc. Accomplishing a task of this magnitude is well beyond my reach; therefore I shall identify the variables in this objective function by using the "dictionary" approach.

A variable will be included in the function if that variable describes a primary focus of a development program of some institution, organization, or agency. Using this criterion as a means of building the function it would appear as follows:

Quality of life = W_1 Purchasing power per person, W_2 Income distribution, W_3 Economic base, W_4 Contributions of institutions, W_5 Infrastructure, W_6 Capital inventory, W_7 Cultural level, W_8 Leadership effectiveness, W_9 Performance of services, . . .

If in a period of time a positive change in this objective function has occurred, community resource and human development has taken place.

The reader should recognize that an objective function developed in this manner is designed for communication purposes and not intended to be a mathematical model. This function will be used to communicate the content of community resource and human development, to indicate past problems and present difficulties, and (it is hoped) to point up a few directions in order to struggle out of the present confusion. This function could be viewed as a method of indicating the gross social product of a community.

The possibility of additional variables is indicated. Identifying the above variables does not suggest that the list is complete and will insure quality living. Other variables have been suggested and undoubtedly are important: "reconciliation of hate, fear, and distrust" [7, p. 25]. Some variables have not been included because no resource development programs have been focused on them. Perhaps new programs are needed in order to supply the missing components, or, as some will argue, perhaps the idea of community resource and human development is already too broad to be manageable.

Composition of Variables

Before engaging in further discussion the composition of the variables should be explained, and it should be noted that each variable is weighted.

Purchasing power per person

Perhaps the composition of this variable is more obvious than some others. It considers per capita income adjusted for inflation and differences in costs of living related to geographical price differences. Other less obvious costs are included, such as costs of public and private insti-

tutions and government. If a community is adversely affected by diseconomies of scale (or structural imbalance), correcting this situation will have a positive influence on purchasing power per person. In addition, if the community has a high degree of underemployment (small farms, small towns, small schools, etc.) per capita income will be lowered. In this situation outmigration will have a positive effect on this variable.

Income distribution

Presumably an improvement in the distribution of income (especially without a reduction in purchasing power per person) will improve the quality of living. Any reduction of unemployment or underemployment would accomplish this purpose. Therefore, programs aimed at training or retraining the unemployed, providing jobs for unemployed, and reducing discrimination for reasons of race, color, or sex would affect this variable. In addition, public policies such as the progressive income tax or welfare will have a significant impact.

Economic base of the community

This variable has two primary components, the first of which is the number of full employment jobs. The type of service or institution that is supportable (and the unit cost of this activity) is directly related to the economic base. Many small towns and hamlets survive because they are willing to forego some services that are expected in larger centers. Very few communities can support a major league baseball team or a symphony orchestra.

This, however, introduces the second consideration—the concept of community. There is a rapidly growing acceptance that many nonmetropolitan communities (small towns) of 50 years ago are no longer viable owing to the impacts of technological developments. The "area" approach to nonmetropolitan development is growing in favor. One such community concept is the multicounty central city community introduced by Karl Fox as the functional economic area. Acceptance of the FEA idea gives the residents a much larger economic base for planning purposes and offers access to services and institutions that would be impossible in each and every small town. Therefore, any program using the multicounty base tends to enhance the acceptance of the FEA as "the community" and makes the potential for development greater.

Contribution of institutions to society

Institutions include educational (public and private), government (local, state, federal), and church. This is an important but an elusive variable to explain. If the outputs of our institutions improve in a manner that moves our society closer to its goals, the result is a positive influence on our objective function. It is difficult to be more explicit. Some aspects of this contribution can be identified as an improvement in individual and collective productivity as valued by society. It includes the ability of institutions to deliver a greater variety of valued outputs. It includes a change in the utility function of individuals permitting them greater appreciation and satisfaction. It also includes the maintenance (or improvement) of our environment in a manner that permits society to effectively perform its functions. It also includes an improvement in moral responsibility, a sense of justice and equality insofar as these are viewed as outputs of our institutions.

Infrastructure

This term is used as the physical planner's concept of the access and mobility of people, products, and ideas. If lack of roads, transportation, or communication facilities place the community at a disadvantage relative to other communities, the improvement or addition of the limiting facility should have a positive influence on the gross social product or should improve the prospects for a positive change.

Capital inventory

This variable includes the investments that affect the capacity to produce goods and services and is somewhat like the infrastructure in that the immediate change is investment. The expectation is that long-run results will prove that the investment caused actual production of goods and services to increase.

Cultural level

One definition of culture is "acquaintance with and taste in fine arts, humanities, and broad aspects of science as distinguished from vocational, technical, or professional skill or knowledge." For purposes of this paper I include aesthetic improvement (artistic, beautiful) as well as cultural. It is the assumption that an increase in fa-

:ilities and programs related to cultural and aes-:hetic aspects of a community will cause a posi-:ive change in living satisfactions. The improve-nent in the ability to appreciate cultural and ıesthetic community components could be con-;idered human development.

.eadership effectiveness

Effective leadership is defined as having as a ;oal the positive changes in the objective func-ion. If a community can achieve cooperation ınd support for realistic objectives from its for-nal and informal leaders, its organizations, insti-utions, and groups, there is a high probability hat effective leadership exists. This leadership ıas the ability to organize and coordinate com-nunity resources and efforts. It has perspective, hat is, an understanding of a wide range of is-ues, with the ability to recognize and choose be-ween realistic alternatives and to maximize re-urn for efforts expended. It develops a realistic ıttitude of trust, cooperation, and willingness to nvest time and effort on the part of the commu-ity residents. Innovation is welcomed, organiza-ions are active, fund drives and bond issues are 'iewed in perspective.

The community through its leadership has ac-ess to the outside world and to higher levels of overnment. The community power structure is ble to motivate and secure cooperation from all evels of leadership for programs that are realisti-ally appraised in terms of success probabilities. 'he leadership develops an understanding re-;arding which activities are local, which are mul-icounty, and which are state or national in cope.

An increase in the effectiveness of this type of eadership will have a positive influence on the otential change in the quality of living.

'erformance of services

The ability to offer a wide range of services to esidents on a competitive basis is the central neaning of performance. This includes retailing, which offers a wide selection of items, quality, tyles, and prices. Repair and customer services with the necessary technical skills for business nd household functions are important ingredi-nts.

Banking and credit services have tremendous nfluence on community efforts. Nonmetropolitan nedical and health care facilities are a serious nd growing concern. Private recreation facilities and programs designed for the enjoyment of residents are important to leisure time uses.

Population

I have chosen to omit population as a variable, even though most nonmetropolitan communities would select this as the first measure of development. Equating population increase with success has been a common practice since Plymouth Rock. If the idea of Spaceship Earth becomes a reality, and I think it will, using a body count to indicate success can no longer continue. Population will then become a constant and not a variable. Population distribution will be the major concern.

Another reason for its omission is that evidence indicates that population can be viewed as a constraint. The New Yorks are so large that serious diseconomies exist and the High Plains have some areas so sparse that diseconomies cannot be avoided. However, there appears to be a wide population range in between where communities are not limited in their ability to increase the objective function (development of quality living) with approximately the same amount of input.

Process or Strategy

There are some "development" workers who ignore all the above variables and claim that development is only a process. They suggest that sufficient motivation will cause miraculous things to happen in a community. I believe that viewing development as strictly a process can be dangerous. It is possible for community leaders to build to such a high degree of frustration as they attempt to solve problems beyond their control that disillusionment results. When this happens the unnecessary discouragement and depression makes renewed interest difficult to achieve.

This statement *must not* be construed as saying the process is unimportant. The process is extremely important, for the strategy (process) will often determine whether or not certain bits of understanding reach the input level of decision-making. However, there must be more than a *process*. There must be a *purpose* for which the process is applied. I believe the purpose is to improve the decision-making ability of community leaders, resulting in a positive change in the objective function described above.

What is community resource and human development? It is a process that informs, involves,

and motivates people of the community to examine realistic alternatives and take actions that result in a positive change in the quality of life as measured by the factors described.

A process, yes—but with a purpose!

Past Problems

Now people are asking (also legislators) why more progress hasn't been made in the past? Why are people still asking—and still bickering over community resource development?

Public leaders are saying we have talked enough; let's have action. As I said earlier, the process alone is not sufficient, but action without the appropriate process is also dangerous. The experience of the OEO undoubtedly illustrates the dangers of too much action and not enough talk. Too much confusion and uncertainty still exists, but some of it at least is understandable.

As we examine the record we see that land-grant agricultural production workers claim to be working on rural development, and they are if they cause an increase in purchasing power per person. The Farmers Home Administration worked diligently on rural areas development and made many grants and loans to small towns for installing water and sewer systems. They were hoping to influence the contribution of our institutions (the small municipality). The Appalachian Commission was criticized for spending heavily on highways rather than on people. They were changing the infrastructure. The University of Iowa received a Title I Higher Education Act grant to do community development. The purpose was to help small communities organize performing little theater groups. Presumably the cultural level would be improved. State Development Commissions are sometimes accused of being interested only in "smokestacks." Their emphasis is on improving the capital inventory. The extension services have tried to train leadership to work on the process, informing leaders on the probabilities attached to variables and how to use the social action process. Other examples could be given. It appears that each group has a different concept of development when in fact each is working on a legitimate variable in the objective function.

Institutions, organizations, and agencies have acted very much like the three blind men and the elephant. While grabbing the tail, the leg, or the trunk and claiming a "hold" on community resource and human development, none has made the effort to examine the entire elephant. Fragmented and competing programs have resulted with very little improvement in tolerance of the other's efforts or an appreciation of the process of achieving a positive change in the objective function.

There are two major problems associated with this situation. First, each development "agent" selected the variable to receive his attention in accordance with his competency. This is understandable. However, the result is to ignore the weights attached to each variable. There has been no consideration given to the question: "Given the quantity of resources, on which variables should they be applied in order to receive the greatest return?" Of course, institutional rigidities might render most of the resources immobile, but the question should still be asked in regard to new appropriations and allocations.

The second problem that emerges is the failure to recognize trade-offs between variables. Each development agent has selected his variable and pursued it without regard to the effect on other variables. The existence of trade-offs cannot be denied. (1) The increase in purchasing power per person in rural areas through the use of technology has caused out-migration which resulted in increased structural imbalance in our institutions. (2) Increasing the community economic base by using an FEA instead of the city limits has implications for leadership effectiveness. No formal leadership structure exists on a multicounty base, and sociologists question the existence of a multicounty social system or power structure. Therefore, leadership effectiveness is a pertinent question. (3) As capital inventory increases and the city becomes larger, leisure facilities can become more costly. Some leisure items that are free in the small town have a cost in the large city. (4) Purchasing power per person could be temporarily increased by using up capital inventory. (5) Capital inventory might be increased by investing funds in industrial parks or "shell" buildings at the expense of culture or recreation. Other examples could be cited. It is quite possible that vigorous pursuit of one variable could have a trade-off effect on another, resulting in a decrease in the quality of living.

To say that we have a positive change in the objective function only when one variable is increased without a reduction in another is not realistic. If this criterion were rigidly followed, very little could ever be done because of the extensive interrelationships that do exist.

Weights

The weight is the indicator of the importance f the variable to the community. If an addiional unit of the variable would return the most in terms of an increase in living quality), then ariable X would have the highest weight. It is ossible that one variable might be limiting, in he sense that other variables cannot be increased ntil variable X is increased. In this case varible X would have a high weight.

When viewed this way weights will be different or each community, and each weight is a funcion of the level of the variable. For example, a ommunity that is inaccessible would place a igh weight on a highway (infrastructure). Howver, if more and more highways are built through his community the weight placed on highways vould decrease. Presumably the weight could beome negative at some point before the commuity was covered with concrete.

A relevant question emerges: Who should lace the weights on the variables? Jim Hildreth 6] says,

> If we accept the assumption that our society is a pluralistic one, we see that the voting and weighing of the votes is the community's privilege and the responsibility is not ours. The outsider's role is to provide the community with information on which to make improved judgments and decisions. These judgments and decisions may differ from one community to the next and from one time period to the next with the same community. The "ask the community" approach will always be a source of discomfort for the well-meaning outsider. It would be much easier for the professional to impose his judgment on the community.

agree that the community should place the veight on the variables, but I would add one ualification. I believe the decisions should be nade by a community that is viable and relevant 1 tomorrow's nonmetropolitan world. This vould place the decision-making base in the mulicounty area or FEA and not in every small own where structural imbalances could be perietuated indefinitely. I shall return to this interiretation of community in the section on recomnendations.

Although the resource development strategy is imed at improving the decison-making ability of eople within a specific community, I believe the ssue or problem requiring a decision need not be imited to specific community boundaries. Some roblems can be decided by people living in an FEA, but many are influenced by state or national policies. The policy decision is larger than one community and often has more influence on development than any decision made strictly within a community. However, the use of state and national policies is frequently subject to some local decision-making insofar as the policy affects the local people.

Dilemma of Measurement

At this point many readers have said to themselves that it is impossible to operationalize this function. It has been impossible in the past, which is the source of much of the difficulty surrounding community resource and human development. Quality of life is a utility concept. Some economists have maintained that no cardinal measurements or interpersonal comparisons are possible.[1] Some sociologists and economists insist that social indicators (indexes) can be constructed and that a gross social product that will pass for quality living measurement can be constructed [1, 2]. If this is done, community resource and human development can move into a new era.

In the past we have been plagued with claims of progress but very little proof. It is difficult for administrators, legislators, or congresssmen to become enthusiastic (and generous with appropriations) over a program that cannot measure its progress or lack thereof. This is especially true when the program has some inherent conflicts with political reality. For example, in many cases the only realistic economic solution leads to farm consolidation, school consolidation, etc. In the local community these acts often run counter to local attitudes and beliefs. Attitudes, beliefs, and emotions are reflected in the political system more frequently than economic reality.

Other conflicts concern time and visibility. Political figures want to point to visible highways, dams, and smokestacks, and they want to do it before their term of office expires. But development is a long-run process and some of the most important components in living quality are far from visible in the short run.

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[1] Ordinal utility functions are sufficient, in economic theory, to guide a perfectly competitive economy to a general equilibrium which maximizes the gross economic product given the initial distribution of resources. The fact that cardinal utility functions are unnecessary for this derivation does not mean that interpersonal comparisons are impossible or undesirable. The "one man, one vote" principle makes a specific, quantitative interpersonal comparison in the political sphere.

The level of some of the variables can be measured: income distribution, capital inventory, etc. Most of these are economic in nature, which partly explains why we have heard the accusation that development programs are often concerned only with economics. Until we can measure the other variables, i.e., performance of services, contribution of institutions, cultural level, there will be no way of determining whether a positive change in the function has occurred. Until some kind of measurement is possible those of us who are interested in the process of informing, motivating, guiding, can only hope that progress is being made.

Conclusion

I have discussed nonmetropolitan community resource and human development as a positive change in an objective function. I have not attempted to specify the contribution of land-grant universities or of economists. However, the importance of the contributions of economists should be obvious. And the importance of other disciplines, other institutions, other agencies and organizations should be apparent. It is a massive task calling for massive input.

Without any intention of exhausting the list of future needs, I shall suggest a few that appear to be extremely important if community resource and human development programs are to make significant progress in the future.

1. Research needs are enormous. Until research has accumulated a body of knowledge comparable to that in agricultural production, information efforts will be limited in scope. One primary need has already been mentioned, that of measurement of levels of variables and a gross social product. Other research needs are measures of institutional output and analysis of alternative structural arrangements in nonmetropolitan areas, including analysis of alternative school systems, health care, government, transportation, and rural services.

Information is needed on how people could weight the variables in terms of priority. Perhaps this should be done by size of community as well as for the multicounty area. Such research results would undoubtedly produce differences related to geography or location in the nation.

2. With so many swimmers (institutions, organizations, agencies) in the same pool, confusion is understandable. Coordination is a great need, but difficult to attain. No one wants to be coordinated by someone else. The responsibility for coordination lies with the people of the community, as does the responsibility for setting priorities. However, an effective mechanism is needed for accomplishing this coordination. Part of such a mechanism is now available; part is not. A multicounty planning group can, if they wish, do an effective job of placing weights on the variables representing the wishes of the majority of the people.

It is the function of institutions, organizations, and agencies to provide inputs into the planning process as needed. This type of planning is now possible and is being used by many communities. The primary difficulty is that multicounty planning groups have no multicounty government to implement the plan. If local school districts, municipalities, and county governments must do the implementing, only those things that have universal agreement and support can be carried out; and these are very rare indeed. Voluntary groups can inform and motivate but have no ability to implement.

Multicounty planning has great potential if we have a multicounty government working as a partner with the responsibility for implementing the plan to achieve a positive change in the objective function for the majority of the people in the multicounty area [3]. Since planning and implementation are continuous processes the inputs of organizations, institutions, and agencies would also be continuous.

3. Finally, I would like to emphasize the need within the land-grant universities. The potential input of the university into successful community resource and human development is tremendous; in fact I seriously doubt the possibility of success unless the universities provide this input. This program is of necessity multidisciplinary. Many university departments and colleges are (or should be) directly involved. If this involvement is individual and random, at no time can the "critical mass" be assembled for program impact.

The critical mass includes problem-oriented research directed at the problems as the multicounty government and planning groups list their priority. It includes an extension delivery system coordinated with research. It includes assistance to local action groups who ultimately take the steps to produce a positive change. Land-grant universities need this type of mechanism if university resources are to make their greatest contribution to community resource and human development.

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Discussion: H. A. WADSWORTH, Purdue University

The common and accepted usages of a term may adequately describe an existing situation, but they do not necessarily define the dimensions of either a research or an educational program. Community development as a mission of land-grant universities should be a program whose purpose is to assist in resolving community problems. Dynamic political, social, and economic conditions challenge us to apply our knowledge to allocation problems that are not strictly of an economic nature.

In achieving our purpose we must rely upon research analysis and education to influence public and private decisions that lead to improved quality of life, standards of living, and human conditions.[1] Such decisions are made at national, regional, or community levels as well as on an individual basis. Thus, the important problems to be researched are those requiring decisions at one or all of the various levels, and the clientele for extension becomes those people who make decisions at these levels. Choices made among alternative research or extension programs will be based primarily on anticipated impact.

Eldridge argues that there is a commonly held objective for community resource and human development. Specification of his objective function would appear to be of secondary importance to a responsibility to acquaint the decision-maker with possible alternative choices before critical decisions are made. This would cause us to be primarily concerned with the development of additional alternatives to existing and future problems. Equipped with such alternatives, the decision-maker appears competent to utilize his objective function to make the decision without our being able to specify it for him.

Effective programming requires us to define decision areas more precisely than Eldridge does in his listing of variables. The column headings of our map specify decision areas as perceived by decision-makers. Each cell in the column recognizes that additional refinement of the decision area is necessary in order to relate to the decision-maker. Further subdivision is possible as decision areas are identified as being public or private in nature.

In reviewing past accomplishment and planning future programs, the map may be as useful to other scientists as to ourselves. As economists, we will find economic aspects in each cell. We should anticipate that economics may not play as dominant a role in these decisions as in those with which our efforts have been more closely associated in the past.

It will be argued that the profession does not possess the expertise needed to contribute effectively in resolving problems of such nature. As applied economists, we should be sufficiently well trained that we can apply economic analysis to such problems. Our contribution is not limited to economic aspects but pervades the entire framework. Allocation is one of our major concepts, and we should be relatively better prepared than most to incorporate economic, social, and other considerations into a framework that would facilitate decision-making. In this sense agricultural economists may find that they can play leading roles in developing institutional commitments within our land-grant university system for relatively more emphasis on the problems of people than in those of disciplinary origin.

[1] I am indebted to the North Central Regional Strategy Committee 3, Rural Community and Human Resource Development, for this framework. Particularly, I want to acknowledge the contributions of George Beal and Leo Mayer of Iowa State University and R. J. Hildreth, Farm Foundation, who helped conceptualize the research map.

Discussion: JOSEPH D. COFFEY, U.S. Department of Agriculture*

Rather than critiquing Eldridge's paper, I shall take advantage of the latitude Chairman Henry Meenen gave me to review rural development from the federal perspective.

Most persons would probably concur with the statement that to date rural development efforts of the federal government have essentially failed. True, there have been many successful projects and communitywide programs over the past several years, but despite these successful battles the overall war has not been won. Why is this so? Let me mention four reasons.

1. Lack of commitment: There has not been a unified, coherent, purposeful national policy and effort for population distribution and rural development. The support of rural political forces has been inadequate.

2. Fragmentation: Federal government's capacity to do things is exceedingly fragmented and broadly scattered throughout the federal establishment.

3. Errant programs: Many of the well-intentioned federal programs have been plagued by negative and inhibiting side effects. Key among these problems are inflexibility, priority distortion, and flawed accountability. Existing welfare programs are not well designed nor suited to rural residents. The upshot has been that rural poor have been "left behind."

4. Lack local involvement and support: The people that our rural development efforts are supposed to benefit have not been sufficiently involved. Rural areas will not move forward unless the local people want it and promote it. But local involvement is not sufficient. There must be agencies, programs, and officials receptive to their concerns and with the know-how and resources to act upon them. The private sector must be involved in a major way.

Now I wish to turn to key elements of a strategy which it is hoped will overcome the past failures.

1. *Balanced growth policy:* Rural development is a component of an overall policy of balanced population distribution. This overall policy is not complete, but there has been progress toward it. Key elements are educational excellence for rural youth and accessibility of essential government services to every American regardless of where he lives.

2. *Strong economy:* Essential to the success of a national rural development policy is a fully employed and growing national economy. A prosperous economy is essential not only to insure full employment; it is necessary to generate the government revenues needed for publicly supported services and facilities.

3. *Reform:* Reform and restructuring of federal programs and agencies to reduce fragmentation and duplication, minimize red tape, strengthen flexibility and capacity of local people to act more directly on their own problems and overcome inequities is another major part of a national strategy. Grant consolidation, welfare reform, government reorganization, decentralization, revenue sharing, block grants, etc., all represent facets of efforts to make government more effective and responsive.

4. *Location of government offices and facilities:* Where government conducts its business and locates its facilities can significantly affect future growth patterns. Thus, one way to foster development of rural areas is to locate federal facilities in rural areas wherever this can be done without sacrificing program effectiveness.

5. *Industrialization:* Private industry must be encouraged to expand jobs in rural areas. Private firms are not going to locate or expand in rural areas simply because we want them to; they must be able to earn a profit; they must know about the opportunities. We must continually insure that our programs and activities to encourage rural industrialization are adequate and not counterproductive.

During the 1970's a projected $1.5 trillion will be spent on construction and $1 trillion on community and human resource development whether or not there is a national rural development policy. Unless some of the past inadequacies are overcome these trillions of dollars will reinforce existing population concentrations and magnify rather than mitigate the problems of rural and urban residents alike.

* These views do not necessarily represent the views of the U.S. Department of Agriculture.

Human Resource Development

CHAIRMAN: J. MARTIN REDFERN, UNIVERSITY OF ARKANSAS

Economic Aspects of Human Resource Development*

FRED H. TYNER, UNIVERSITY OF FLORIDA

SUBTOPICS discussed in this paper are: (1) relating human resource development to other development topics; (2) criticisms of past effort; (3) is there a policy for human resource development? (4) elements of the human resource development problem; and (5) research approaches needed.

Human resource development is seen to be one of several interdependent elements of the "rural development process." Other elements of this process are community development, economic resource development, and natural resource development (in special cases).

A narrow definition of human resource development would include peoples' training and skills, values, attitudes, and their goals for their families and communities. Because of the interdependencies of the elements of the rural development process, it is suggested that the needs of human resource development are best studied in relation to community development and economic resource development.

Past efforts in behalf of human resource development have been criticized for our failure to understand more "about the way people live or the costs and effects of improving the manner in which they live," and our emphasis on designing programs "to adjust poor people rather than the conditions that make people poor." In the confusion of interpretation regarding what is meant by rural, by community, by development, by human resources, etc., we appear to be exhausting our energies in seeking to apply the proper nomenclature rather than in selecting researchable problems and seeking outputs (answers) that will be useful to public decision-making.

Benefits of past programs have been linked principally to land and capital resources. Rural people with little or no holdings of land or capital have apparently been substantially" abandoned by public policy." Whether these observations warrant a conclusion regarding the presence or absence of a public policy for human resource development is a moot question. In view of the complexity of defining a human resource development problem, it is not surprising that there is no identifiable, comprehensive policy for human resource development. It would seem to be more relevant in this case to work on those aspects of human resource development needs for which research questions can be explicitly defined.

The basic element of the human resource development problem is that (generally) rural people are inadequately prepared to fully participate in modern society. Contributing factors are inadequacies in educational preparation, occupational choices, business ability, employable skills, effective use of their personal and financial resources, and the effectiveness with which they adjust to social and economic change.

The objective of this paper is to encourage agricultural economists to direct their research attention to (1) supplying the basic data needed for identification of major problems; (2) outlining the possible alternative solutions to these problems; and (3) determining the gap between resource availability and needs, with suggestions as to how this gap can be narrowed.

Suggested fruitful areas of research are (1) costs and returns to public services such as education, health, welfare, etc. and (2) cost effectiveness analysis of alternative means of providing these public services. Specific research problems suggested are (1) efficiencies of local government consolidation; (2) optimum location of services such as schools and hospitals; (3) delineation of functional socioeconomic areas for planning in order to achieve effective economic development; (4) analysis of major economic linkages among producing, business, and public services sectors; and (5) similar examples of applied, problem-oriented research to provide planners with assistance in achieving economic development, which implies progress (both before and after the fact) in human resource development.

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* Abstract.

Discussion: Kurt R. Anschel, University of Kentucky

Tyner objects to the continuing discussion of the terminology of rural development. Isn't this discussion an essential component of the broader controversy surrounding the solutions to rural decay?

Public goal conflict is inherent to the American political system. In addition, the efforts towards rural development seems to include an unusual degree of inconsistent and conflicting programs and regulation. Two hypotheses are suggested for the cause of these conflicts. First, we have not achieved a sufficient understanding of the solutions to the problem to arrive at a consensus among policy-makers. Moreeee fundamental, perhaps, is the conflict among the interest groups seeking to achieve rural development. These groups are the rural poor, the rural affluent, and urban interest groups. Each views rural development from a different perspective and with somewhat conflicting aims. Different public agencies are responsive to these groups. The result is a conflict in the programs of these agencies.

I substantially agree with Tyner's list of research priorities. Specific research topics into generating and maintaining rural human resources are suggested.

Discussion: John H. Sanders, University of Minnesota

Public policies for rural development can be categorized into programs involving income transfer, programs attempting to attract industry, and programs leading to out-migration. If the primary objective of program design is to alleviate rural poverty, the most effective program is a transfer program specifically for the rural poor. Public policies that subsidize industrial decentralization are similar to price supports in that they are often justified as solutions to rural poverty (and presently as solutions to urban poverty and the pollution problem), but the benefits of these programs are primarily captured by the owners of capital.

Programs leading to successful out-migration may be very effective in raising the income of the rural poor. Data for a group of migrants from eastern Kentucky indicated that the average annual money income in the industrial area was $2,600 higher and real income was $1,700 higher than in eastern Kentucky [1, p. 448]. Moreover, the ability of these migrants to obtain only marginal jobs in the industrial area appears to be due to insufficient public investment in their human capital. The private rate of return on migration may be significantly augmented by increasing the complementary public investments in human capital to enable the rural migrant to more effectively compete in the industrial job market. High rates of return to migration outside the community of origin indicate the need for increased federal financing of rural human resource development.

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Role of Selected Social Sciences in Rural Development

CHAIRMAN: MAURICE M. KELSO, UNIVERSITY OF ARIZONA

The Interface of Political Science and Economics in Rural Development*

LAWTON E. BENNETT, NORTH CAROLINA STATE UNIVERSITY

ELDRIDGE's model for an objective function for development makes many demands on local political systems. They must be able to plan, to make effective decisions, to deliver services, and to involve a participant public. Most rural governmental units, however, lack the organizational form, the leadership, the citizen support, or the scale of operation to contribute effectively to these activities. Changes should be made to provide for effective leadership, rationalized organization, to involve and mobilize citizens, and to increase scale to gain a viable base.

The manager form approximates some of these goals but lacks effective political leadership for policy direction. Increased participation must cope with apathy, which frequently has many roots, and must build on deliberate efforts to improve channels of access. Increasing scale presents many dilemmas. Several criteria for appropriate scale fail to provide any definitive guide to optimize scale and are even in conflict with each other. Particularly, actions to improve efficiency and control through increasing scale may conflict with citizen preferences and may inhibit participation.

A compromise approach to reorganization is a transitional federal form. This would divide local functions between two levels to strengthen organizational effectiveness while maintaining the local centers for citizen involvement and access.

In gauging the comparative roles of political and economic factors in accounting for differential levels of local governmental services, a recent review of research suggests that the economic factors account for most of the variation while the political factors fill an intervening role. However, the measure of governmental service contains an economic bias and does not reveal the dynamic process of political decisions and actions that might contribute to development.

* Abstract.

The Interface of Sociology and Economics in Rural Development*

James R. Finley, Battelle Memorial Institute

During the course of this paper three major areas are explored. First, a definition of rural community development is offered. Second, some of the similarities and dissimilarities of economics and sociology in rural development are explored, both from substantive and from pragmatic perspectives. Third, an illustration of the research sociologist at work in a rural development problem is developed. On the third point, a case study of water resource decision-making is described, with appropriate concepts developed so that a better understanding of conflict in development efforts may evolve through sociological analysis.

* Abstract.

The Interface of Anthropology and Economics in Rural Development*

THOMAS WEAVER, UNIVERSITY OF ARIZONA

THIS PAPER grew out of a critique of a paper presented by Eber Eldridge entitled "Community Resource and Human Development" in which I tried to point out some of the differences in terminology and methodology between anthropology and economics. The major criticism made of agricultural economics is that it fails to account for the structure of values and social organization of the community in which it is trying to induce change.

The model presented for consideration relates to the anthropologist's use of the concept "culture" as a holistic principle that encompasses the views, notions, values, and desires utilized by a particular group of people living in a single locale to guide their behavior and to adjust to the "physical, social, and political environment. This use of "culture as an adaptive mechanism" takes into consideration the fact that succeeding generations of people must continually adjust their culture to changing circumstances. From the view of the agent trying to induce change it means that he must take into account the values and desires of that community, as well as its customary ways of getting such things accomplished, which involves an existing political and economic structure of roles and relationships. The change agents plan must thus be accommodated to the ongoing culture (subculture) of that community.

Examples were provided in the paper of a rural Spanish-speaking community in New Mexico undergoing change in the context of divisive political and social factional constraints. A group of Southwestern Indians undergoing economic change is described in a similar context in which communication with the residents did not consider their desires and ultimately led to the failure of economic and industrial plans proposed by its leaders. A third example was provided from American communities in which referenda failed over the fluoridation of community water supplies.

* Abstract.

Discussion: BERNAL L. GREEN, Economic Research Service, USDA

I agree with Eldridge that improvements in the quality of life is development. I am concerned that he did not consider quality of life as a group of elements collapsed into this simple form (composite function). A consideration of the individual elements could be helpful in assigning weights to the variables in his function. Theoretical constructs, by Maslow in psychology, were used to make the case that the fundamental definition of development is those activities engaged in by man to achieve five sets of goals (physiological, safety, love or social acceptance, self-esteem, and self-actualization) typically arranged in a progression based on their strength. To the extent that these human goals are met, quality of life (development) is increased.

Insights provided by this multifaceted perspective are:

(1) The weights on the variables influencing quality of life will depend on the measure that each group in society has achieved the five basic goals; the relative magnitude of the weights are cyclical in some cases (psychological) and episodic in others (safety). After a need is gratified its weight drops to zero until it reemerges. The main contemporary aspect of development in the United States calls for creation of an environment more favorable to self-esteem and self-actualization, and research should consider these aspects more explicitly.

(2) Any group who is thwarted in achieving (say) the most powerful goal will react accordingly (social disorganization), and coercive force will meet a stiff test of strength.

Contributed Papers
(Abstracts)

CHAIRMAN: MAX F. JORDAN, ECONOMIC RESEARCH SERVICE, USDA

The Economist and Rural Development: Concepts and Conflicts

DANIEL W. BROMLEY, UNIVERSITY OF WISCONSIN

DOMESTIC colonialism is said to prevail in rural areas where the bulk of important decisions that affect rural residents are made elsewhere. This domestic colonialism is the result of both economic and sociological changes. Examples are the change in demand for the "products" of the areas; a shift in the comparative advantage of rural areas, exhaustion of the resource base; structural changes in rural industries; the rise of job rather than neighborhood affiliations; the replacement of national for local allegiance in politics, athletics, etc.; increased impersonalization; and changing values regarding the "good life." Rural communities largely exist as sources of raw material for the metropolitan sphere and, to a lesser extent, as markets for the finished product of that same sphere.

There are at least three possible economic interpretations of rural development: (1) the aggregate demand approach; (2) the equity approach; and (3) the efficiency approach. Since each has different premises, policy prescriptions that each implies are obviously different. However, each still tends to be "task oriented" in nature, an approach that may be at odds with policy derived from a sociological view of development. Sociologists view the web of interactions within a community as having both horizontal and vertical components. The former are characterized as structural and functional relations of various units and systems of the community to *each other;* the latter by the structural and functional relations of its units and systems to *extra*-community systems. A sociological view of "development" is likely to focus on the nature of these two kinds of interactions.

If the sociological notion of rural development is taken, this means the weakening of the vertical ties and a corresponding strengthening of the horizontal ties. Yet the task-oriented approach which economists tend to advocate is not only likely to be a zero-sum game, in that one community is vying with others for the scarce footloose industries and/or capital, but will tend to strengthen the vertical ties with a corresponding weakening of the horizontal ties. This is so because the majority of industry that might be induced to locate in rural areas is part of a larger operation and would be more closely linked to its main office (extra-community) than to other systems within the rural community.

Hence, while there are fruitful areas for cooperation between sociologists and economists, such as in defining the "viability" of a community or in detailing its comparative advantage, the central issue that must be rationalized concerns the notion of "development." As long as the two disciplines hold such disparate views of development, the definition of viabiilty or the notion of comparative advantage will be impossible to deduce. Given this, meaningful policy prescriptions to aid rural communities are highly unlikely.

Some Aspects of Scale Economies Among Missouri Area Vocational Schools

Donald D. Osburn, University of Missouri, and
Frank H. Goishi, Fresno State College

One of the most significant contributions of the Vocational Education Act of 1963 was the authorization of federal funds for construction of area vocational-technical school facilities.

In Missouri some 37 school districts have in operation or have secured approval for the establishment of area vocational-technical schools. During the 1966–1968 biennium some $42 million was spent on vocational-technical education in Missouri. This expenditure, from local, state, and federal sources, represented a 58 percent increase over the 1964–1966 biennium. Because of the magnitude of resources involved and their rapid growth, inquiry into scale economies in facilities for public vocational education has not received adequate treatment by researchers.

This investigation of economies of size was confined to the regular day vocational program offered in the area vocational-technical schools of Missouri. Cost data collected pertained to shared-time type of secondary area vocational-technical schools with permanent separate plant facilities in operation during fiscal year 1968–1969. Fifteen schools met these qualifications.

Costs incurred by these schools consisted of current operating expenditures (administrative costs, operation and maintenance cost) and capital outlay expenditures associated with equipment and physical facilities. Annual depreciation of plant and equipment was estimated by the straight-line method, then converted to a per student cost. Plant depreciation was distributed equally among total enrollment; equipment depreciation was allocated by enrollment with respect to curriculum and program area.

Current expenditures per student ranged from $387 to $609. The mean and weighted mean were $468 and $455 respectively.

Complete equipment inventories was a prerequisite for estimating total cost, and only seven schools had such inventories. Mean and weighted mean for total cost per student were $568 and $545 respectively; the range was from $464 to $735. In short, fixed cost per student was approximately $100.

In order to quantify the relationship between expenditures per student and size, expenditures per student (dependent variable) were regressed on selected independent variables hypothesized to be correlated with expenditures. Stepwise regression techniques were used for the analyses. Number of students (X_1), number of students squared (X_2), average teacher salary (X_3), tax levy (X_4), assessed valuation per student (X_5), student-teacher ratio (X_6), and number of classes (X_7) were the independent variables chosen. Two separate models were investigated.

Model 1: This regression equation included only variables X_1 and X_2 (size of school and size of school squared). Estimated parameters for the equation were: $Y = 764.65 - 1.808X_1 + .00227X_2$. R^2 was .51. The "optimum" size, or size with the least cost per student, was found to be 398 students, computed by taking the partial derivative of the above equation, setting it equal to zero, and solving for the number of students.

Model 2: This model included all the selected independent variables. Results of estimating the regression coefficients were as follows:

$$Y = 31.89 - 1.961X_1 + .00201X_2 + .0681X_3 + 58.761X_4 + 3.74X_7$$

The regression model showed that size of school, size of school squared, teacher salary, and tax levy were correlated with expenditure per student at the .05 level of significance. Approximately 81 percent of the expenditure variation among schools was explained, and the optimum size school was 488 students.

In conclusion, the authors do not wish to imply limiting vocation training to large schools; 60 percent of the schools had enrollments below the optimum size (398 students) estimated by Model 1. However, administrators, policy-makers, and taxpayers should be aware of the expected costs under current educational technologies associated with alternative size schools so that rational decisions regarding size of area served, school location, curriculum, and program area can be formulated.

Economic Impact of a Growth Center Through Development of a New City in a Rural Area

Robert R. Fletcher and Daniel D. Badger, Oklahoma State University

The objectives of this paper are: (1) to discuss briefly the justification for stemming or reversing the out-migration flow from rural areas through development of new cities: (2) to relate some basic concepts of growth pole theory to the development of a new city; (3) to establish the assumptions for development of a new city and select nine industries as its initial development base; and (4) to utilize an input-output model to analyze the impact of this new base on final demand, output, employment, population, and income.

The study area was the 54-county area of southern Kansas in the Arkansas River Drainage Basin. With the likelihood that sometime in the future navigation will be extended into Kansas, a hypothetical city, Port Fabs, was selected as a new growth center. This city actually would be developed around or near one of three existing small towns—Winfield, Arkansas City, or Coffeyville. All three of these cities qualify as a growth pole or center as defined by Perroux, Fox, Berry, and others. Both federal and state inducements would be needed to subsidize the initial development efforts.

To demonstrate the use of the input-output model in estimating the regional impact from the development of Port Fabs, we assumed that nine new industries employing 5,800 people, for delivery to final demand in 1980, would be located in the new city. The nine new industries are in four major economic sectors: (1) agricultural processing; (2) chemicals; (3) metal, machinery, and equipment; and (4) other manufacturing. This mix of industries would provide job opportunities for both blue- and white-collar workers of both sexes. College-trained graduates for managerial positions would be needed also. Such a mix would both retain homegrown talent and attract middle- and higher-income earners from other areas.

The impact of establishing the proposed industries can be measured through the application of the input-output multipliers. Increased industrial production for final demand was estimated in terms of employment. Additional deliveries to final demand by sector (as a result of the new firms) were calculated by applying the direct employment requirements to the projected dollar output per man-year of labor for 1980. In addition to the direct employment of 5,800 people in 1980, these industries would (1) create an increase in final demand of $398.7 million; (2) increase output of the area economy by $874.9 million; (3) create a total of 17,795 jobs in the *area;* (4) result in 14,796 new jobs in Port Fabs; (5) stimulate an additional or "new" population of 42,724 persons in the city; and (6) increase household income in the area by $168.9 million.

The future of new cities, including directed growth of existing small towns in viable areas, will depend on the attitudes of the people and actions of our policy decision-makers at all levels of government. If a small city relies heavily on local retailing, with only very small firms for its industrial base, it will tend to deteriorate. If a city relies mainly on manufacturing it may tend to become middle-sized. However, if in addition to having several medium-sized manufacturing firms it has a good industrial mix of other activities, the new city can become a *viable growth center.*

Economic Payoff from Subsidized Labor Mobility

Rod Walker, Oklahoma State University

The Department of Labor through the Manpower Development and Training Act has conducted several labor mobility pilot studies. The question arises whether there is any positive economic payoff. The costs, future income streams, and rates of return are negative for the Hartford Project, 23 percent for the Minneapolis Project, 73.1 percent for the Mississippi Project, and 41.7 percent for the overall average. These rates of return compare favorably with other government and private investment alternatives. The estimates quantified in this study indicate that subsidized relocation, if properly administered, is an effective means of help to unemployed and underemployed individuals.

Implications of Socioeconomic Goals and Attitudes of Cattle Ranchers on Rural Community Development in the West*

Arthur H. Smith and William E. Martin, University of Arizona

Our argument is that cattle ranching in Arizona, and possibly in the whole arid Southwest, is no longer a subject for discussion under "commercial agriculture" but has become a legitimate field of inquiry in "community development and human resources."

Previous research has shown that market prices of Arizona ranches are above a rational value based on the capitalized value of returns from beef production. Including the effects of land appreciation, income tax savings, or opportunities for leverage in the computation of net returns does not explain the difference between expected and actual market prices. We view ranches as both a production and consumption good and hypothesize that the nonmonetary aspects of ranching are additional outputs that carry exchange value in the market and cause ranch sale prices to be significantly higher than expected under a production economics framework.

Factor analysis is used to discern and classify the important goals and attitudes commonly held by a sample of Arizona ranchers. These goals and attitudes are (1) family fundamentalism, (2) income goal, (3) land fundamentalism, (4) agricultural orientation, (5) rural fundamentalism, (6) wealth goal, (7) conspicuous consumption, (8) immobility, (9) income satisficing, (10) local orientation, and (11) local social satisficing.

Discriminant analysis shows that the nonmonetary factors of land fundamentalism, conspicuous consumption, and rural fundamentalism are the significant factors in explaining why some ranchers choose to sell their ranches while others do not. Discrimination is made with 80 percent accuracy. Economic variables will not distinguish between groups.

In addition to the attitudinal factors listed above, the tenacity with which present ranch owners intend to keep their ranches is dependent upon the expectation that their children will go into ranching and upon the availability of outside sources of income. Eighty percent of the ranch owners interviewed had outside jobs or income with which to help support the ranch; 20 percent rely on the local rural community for economic support in the form of nonprofessional or nonmanagement jobs. Nearly 50 percent of present ranch owners anticipate that their children will go into ranching and forego alternatives elsewhere; it is likely that the children will have to take outside jobs in the local area in order to maintain the ranch as a home and way of life. The median age of an Arizona rancher is nearly sixty years; if his children do not wish to take over the ranch, the ranch will most likely be purchased by an investor who is not significantly interdependent with the local community.

These facts have implications for the survival and development of small towns in the West. The availability of jobs in the local area may have stronger impact on the survival of current ranchers than the ranches have on the viability of the local community. The impact of ranching on the local economy may be found more in terms of dimensions such as social stability and community leadership rather than in economic benefits, since resources employed in cattle ranching are underemployed. The implication is that the town keeps the present rancher going; one might suggest the hypothesis that ranching has no economic impact on the town and that an alternative use of the local rangelands would enhance its economic viability and growth.

* Abstract of Arizona Agricultural Experiment Station Journal Paper 19.

Contributions of Agricultural Processing Industries to Rural Development Objectives

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INDUSTRIALIZATION has frequently been advocated as a means of solving the surplus-labor and low-income problems typifying many rural areas. This has been especially argued when a region or country is a large producer and exporter of primary products. The argument follows that regional development in terms of increased incomes and employment opportunities is enhanced if the primary material is carried through additional reduction and/or processing levels before exporting. The objective of the paper is to measure the impact on development in a rural state from processing available agricultural products. More specifically, attention is directed to (1) determining the short- and long-run employment benefits from private investment in the agricultural processing sector; (2) measuring the short- and long-run private investment cost per job created by agricultural processing; and (3) evaluating the potential impact on state employment from national growth in agricultural processing.

The specific objectives were evaluated with the Oklahoma social accounting system and simulation model. The accounting system was divided into (1) a capital account; (2) an interindustry account; and (3) a human resource account. The simulation model was formulated around the basic Leontief input-output system. The complete multisector recursive model consists of 51 major equations.

Short- and long-run employment multipliers were derived for each endogenous sector to measure the benefits occurring from private investment in each sector. The petroleum processing sector has the largest short-run employment multiplier at 7.25. Agricultural processing has the second largest short-run multiplier at 6.29. In the long run, the petroleum, agricultural processing, and other manufacturing sectors have the largest employment multipliers at 6.25, 6.25, and 3.13 respectively.

Private investment costs per job created were determined for each sector. In the short run, direct sector investment creates jobs directly in the sector receiving the investment and indirectly in the remaining sectors from the interaction among sectors. The agricultural processing sector has the lowest short-run investment requirement of $204,000 per 100 jobs created directly and indirectly. Sectors following agricultural processing with lowest investment cost per 100 jobs created were construction, wholesale and retail trade, and services. In the long run, employment is increased directly, indirectly, and induced. The agricultural processing sector requires $205,000 of private investment to create 100 jobs ten years later. Following this sector in order of increased investment costs were construction, services, and wholesale and retail trade.

The favorable position of agricultural processing in terms of low direct investment cost per 100 jobs created in the short and long run has little relevance in attaining state development objectives if there is little potential for national growth in demand or if Oklahoma is unable to capture increasing shares of the national market. If Oklahoma increases its share of U. S. agricultural processing employment by 10 percent, total state employment will increase by 4,702 man-years in the short run and 5,524 man-years in the long run. Further processing of agricultural products in a predominately rural state will not go far in meeting rural development objectives of increased employment opportunities.

ENVIRONMENTAL QUALITY PROBLEMS—NATURE, CAUSES, AND APPROACHES TO SOLUTIONS: IMPLICATIONS FOR AGRICULTURAL ECONOMISTS

PROGRAM ORGANIZER: K. R. TEFERTILLER, UNIVERSITY OF FLORIDA

Agrisystems and Ecocultures, or: Can Economics Internalize Agriculture's Environmental Externalities?

MICHAEL F. BREWER

MY invitation/instructions for this background paper were delivered in sweeping and rather open-ended terms. I was told to stress environmental issues relating to agriculture, to focus on their qualitative dimensions, to derive a useful typology for the problems we are likely to encounter over the next couple of decades and discuss the profession's ability to cope with them. What this implies about the risk-taking proclivities of our Association's officers led me to expect a meeting in Las Vegas.

Purpose, Scope, and Method

The gauntlet having been picked up, weapons and range must be established. I would like to focus on generic environmental quality problems within the agriculture sector of our economy. I shall identify a set of such problems—ones that I believe can be resolved only through recourse to public policy—comment about their tractability, and indicate the sorts of things our profession might do over the coming decade to contribute towards their solution.

Discussing possible future problems can be an endless endeavor. Both spatial and temporal perimeters need to be established. I want to look at problems likely to reach critical proportions during the decade of the 1970's. Many of them reflect the cumulative consequences of physical and social processes, or technological trends that have been with us for some time. Criticality, as manifest in a widely felt need for redress, may result from progressive deterioration of a situation, a more accurate understanding of how bad circumstances really are, or from changes in aspirations. Both sharpened awareness and shifts in social values are reflected in contemporary environmentalism. Some of these value changes are objectively discernible and even measurable; others are of more qualitative character, depending upon the perceptions held by individuals affected. Perceptions, in turn, are heavily influenced by available concepts and by the educational and sensitizing results of dialogue to which those individuals are exposed. Thus, the type of attention and discussion accorded environmental quality problems by the profession will partly determine the priorities they receive. This is not tautology, but an example of the process of "social learning" which is transforming the traditional sphere of concern of agricultural economics.

The spatial context of our subject also is difficult to establish. Problems appearing within the agricultural sector (regardless of whether this is defined as rural or nonmetropolitan) often have their roots in the urban and metropolitan areas. Certainly the costs and benefits of reallocating rural resources can occur in other economic sectors and localities. Rural poor carry burdens of poverty with them when they move to the cities. Conversely, remedies to problems that are manifest in agricultural areas may entail the mobilization of resources from the urban and metropolitan areas or involve the management of environmental systems, such as air and watersheds, that encompass urban as well as rural areas. Thus, though habitually we may think of problems for agricultural economics being situated either on the farm or "in the country," their full delineation and solution often entail urban and metropolitan areas as well.

To carry out this problem reconnaissance, a brief scenario is developed for the agricultural sector during the coming decade or two. Within this context I shall indicate the principal forces of change and the points at which these forces impact upon the agricultural system. In some in-

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stances these impacts create immediate and explicit problems for the management of rural environments; in others, current practices may be rendered obsolescent by these forces, bringing inefficiencies that may escalate over time. Once a reasonably representative set of generic problems is in hand, tactics and strategies for redress can be discussed.

It is hoped this will provide a useful backdrop for identifying opportunities agricultural economics will have for contributing to the solution of these problems.

Uses and Pressures Upon Rural Resources during the 70's and 80's

In sketching out the future scenario from which pressures on the rural environment will emerge, a distinction must be made between the production of food and fiber and other uses for which rural resources will be in demand. If past trends are indicative, there will be mounting pressure on federal policies to modify the present basis on which resources are allocated between these rural constituencies. Much of the demand for rural resources for other than food and fiber production (for example, recreation and long-commute communities in exurbia) is supported by incomes generated elsewhere in the economy. Accordingly, the scenario is developed looking both at production activities and the general setting of agriculture in the national economy.

Food and fiber production

The trajectory that I assume U.S. agriculture will follow over the coming two decades contains no abrupt breaks from the past, although several shifts and new trends are anticipated. Approximately the same cultivated acreage is posited; however, if the greater flexibility in land use permitted under the 1970 Agricultural Act is retained, increased production may be expected even in the absence of genetic improvements and efficiency gains in individual production functions. These opportunities for increased yield per acre will be offset to some degree by changing factor proportions. For reasons developed below, the scenario assumes that land will be substituted for certain capital items, although the extent of this shift is not at all clear.

It is difficult to foresee U.S. agricultural policy without continued program objectives of assisting the small farmer and enhancing his income. However, I would anticipate that increasingly we shall come to think about these problems within the context of a "grandfather clause." Accordingly, I expect a future trend of fewer but larger farms. The metric of size will be both financial and spatial: Future farms will involve substantially greater amounts of capital in combination with relatively small acreages on the one hand, and on the other, larger farms with relatively more extensive use of the land resource. Of these two apparently contradictory trends, I see the latter becoming more important over the next 20 years but subsequently a reverse trend toward substantially reduced acreages and almost quantum jumps in the amount of capital factors applied to those acres.

One important impetus to more extensive agriculture will be the effort to reduce environmentally damaging capital inputs. Information and attitudes currently prevailing regarding hard pesticides have already prompted estimates of how much additional land would be needed to maintain total production if these inputs were phased out [4]. Within regions characterized by certain types of hydrological regimens a similar substitution of land may occur with respect to fertilizers.[1] Several estuarine areas have been found especially vulnerable to severe algal and aquatic plant growth as a result of upstream fertilizer practices. Work currently underway on coastal watersheds in North Carolina have revealed a formidable nitrogen problem in their estuaries. Farm management cost data suggest a set of economic circumstances under which there is little incentive for the individual farmer to modify his profligate use of fertilizer. If circumstances such as these are found to be widespread, we may experience an appreciable increase in the amount of land used in order to maintain current levels of aggregate production.

The countertrend, which I assume will not become substantial within the decade, is based upon a fundamental redesign of agricultural production techniques under conditions in which water, temperature, and nutrient systems of the growing environment are totally controlled. Such circumstances have been alluded to in connection with proposals for large-scale desalting installations. It is not inconceivable that production techniques under such broad environmental controls might be able to increase yield by orders of magnitude. At present, however, our understand-

[1] Similar studies are underway with respect to assumed constraints on nitrogenous fertilizer use.

ing of plant-water-soil-nutrient relationships is far from complete; and though there has been pilot plot experimental work undertaken by the University of Arizona, we still are some distance from understanding the technologies for food and fiber production under those circumstances.

Any scenario of future U. S. agriculture must, of course, consider the international trade aspects. Will the United States be depended upon as a major supplier of food and fiber to the rest of the world? While any prediction along these lines has a low confidence threshold, for present purposes I would assume a continued substantial agricultural export, in which vegetable protein will be an item of growing importance. Obviously the extent to which the trajectory of future agricultural exports will increase will be determined in larger degree by how aggressively the United States pursues trade treaty negotiations. Whether current congressional sentiments towards isolationism and protectionism waxes or wanes clearly is critical.

At a finer grain level one can predict that the general locational trends in agricultural production probably will continue. The migration of livestock production to the southeast can be expected to continue. The relative position of soy beans and other vegetable protein crops also can be expected to increase, though not at the rates experienced in the past few years.

There are some highly conjectural influences related to changing life styles which may have substantial consequences on the food and fiber production patterns. One such shift, increasingly evident among younger people, is towards a more vegetarian diet. A parallel development is, of course, the small rural communes who endeavor to "grow it themselves." While practitioners of these styles are today minute in a quantitative sense, they may increase sufficiently over the coming decade to constitute a significant deflator of future demand for meat and livestock products.

A somewhat parallel development which is occurring in many suburban areas is the "pick-it-yourself farm." These farms usually produce truck crops and advertise at harvesting time for families to come to the farm and pick their own fruits and vegetables. The ones with which I am familiar provide picnic areas, and several operate a farm product retail store. It will be important to assess the income records of such establishments to see whether this type of truck farming is sufficiently profitable to maintain substantial amounts of land in agricultural use in the suburban rings of major metropolitan areas.

General setting of U.S. agriculture

One can predict with somewhat greater certainty the growth of several competitive demands for what traditionally have been agricultural resources. The most obvious of these is the rapidly growing demand for nonagricultural use of rural land which has been manifest both in the diversity of nonagricultural uses and the amount of land sought for particular types of use.

We are perhaps most familiar with recreational land uses. In some instances they compete directly with food or fiber production. An example of this type of competition would be the current disputes within the U.S. Forest Service between recreationists and those advocating increased timber production from the national forest system by more extensive cutting and accelerated construction of access roads. There also are less direct types of competition for land use, which are reflected in the market for agricultural land. An example would be a developed outdoor recreational facility drawing substantial numbers of weekend visitors from a metropolitan area. Concessions and other types of services for visitors to the recreation area may prove profitable and constitute an element in the local land market that enhances land prices. Although the net acreage physically required for these recreationist-service activities may be quite small, the regional impact on the price of land may be such as to accelerate the demise of indigenous agriculture. These developments may occur either in the immediate vicinity of a metropolitan area or in vacation communities some distance from the home ports of the recreationist.

Whatever the particular manifestations of recreational demand may be, over the next 15 years we can anticipate growing population over 15 years of age and increased per capita income, mobility, and leisure time. These are "permissive factors" enabling individuals to participate in land-based recreational activities. The rapid increase in actual participation in such activities over the past suggests that there is abundant motivation for taking advantage of these opportunities.

An additional development that promises to disrupt the traditional farm real estate market has to do with the settlement patterns of the general population. While not anticipating any check in the growth of the great megalopolitan

areas of the United States, we may well experience a geographical broadening of settlement patterns. One motivation for such development is to avoid what many believe are the environmental drawbacks of large urban communities in favor of an amenity-rich, small city somewhere "in the country." Our increasing awareness and documentation of just how congested our urban environments actually are and the types of cost they impose on their residents adds momentum to these sentiments. We are familiar with traffic jams and are learning rapidly to perceive and react to the congestion of urban meteorological and hydrological systems.

If the net effect of congestion entails a reduction of individual welfare, the damage inflicted by polluting activities is highest in densely settled areas. The tendency to impose the costs of pollution on polluters through effluent charges, penalties, and other policy instruments will correspondingly increase their liability in areas of dense population settlement. Accordingly, unless checked by zoning or land use regulation, one may anticipate a growing tendency for these activities to migrate to rural areas, paralleling the dispersion of urban populations in search of residential amenities. A recent example is the concentration of coal-based electrical utilities in the Four Corners Area.

One consequence of a rural migration of dirty industries would be to create employment opportunities in rural areas. Extrapolating over time, one can imagine young communities, perhaps of urban size, comprised of metro defectors, highly sensitive to congestion and pollution, employed by highly polluting indigenous industries. The city council sessions of such communities doubtless would be lively!

What appear to be today's solutions sow the seeds for tomorrow's pollution. Whether these decentralizing trends will be sufficiently modified by regulation, incentives, or planning to result in a viable, long-run solution is an open question. The point here is to suggest that there will be mounting pressures for occupancy of rural areas by individuals who do not have agricultural production as their chief source of livelihood.

Problem Clusters with Which Future Agricultural Economists Will Have to Contend

I want to identify four areas within this projected setting of U.S. agriculture in which new and difficult problems are likely to arise and to which the profession of agricultural economics can make a substantial contribution. These are identified and discussed briefly below.

Residuals problems

Those concerned with environmental quality often have pointed an accusing finger at agricultural activities. Thus far most of the discussions have been either partial, focusing narrowly on some problem or material occurring in agriculture, or vague and excessively general, as in the allegation of soil structure disintegration. One useful way to assess these problems is to focus on the residuals generated by the production, processing, or consumption of agricultural items. A recent estimate indicates that in 1965 about 600 million tons of basic materials were produced from agricultural activities (including forestry, fisheries, and wildlife production) out of a total 2,640 million tons for the entire economy [3, p. 10]. Ultimately all of this material is "recycled" either in the form of residuals generated at various stages of the production, processing, consumption continuum or as more basic substances into which the original material has been converted.

The substance of these residuals may have occurred naturally from agricultural biological processes, or they may have been explicitly introduced from some other sector of the economy, for example, chemical fertilizers and pesticides. The point is that production and consumption activities do result in leftovers that must be reassimilated into the physical environment. It is now widely recognized that we must pay as much attention to the efficiency of waste assimilation as we do to the efficiency of product production. We have far less empirical understanding of assimilation functions than we do about production functions. We know still less about the cost functions of waste reassimilation. These technologies, which determine the form in which residuals will be generated, as well as their timing, location, and ingredients, are rapidly changing. In light of this it is hardly surprising that discussions about agricultural impacts on environmental quality have been fairly primitive. A substantial burden that agricultural economics will have to bear over the coming years is to extend our knowledge about these relationships and identify options for coping efficiently with them at both the farm level and nationally.

From Table 1 one can see that food and other products derived from photosynthesis produce

Table 1. Weight of basic production in the United States plus net imports, 1963–1964

	1963	1964	1965
Agricultural (including fishery and wildlife and forest) products			
Food and fiber			
Crops	350	358	364
Livestock and dairy	23	24	23.5
Fishery	2	2	2
Forestry products (85 percent dry wt. basis)			
Sawlogs	107	116	120
Pulpwood	53	55	56
Other	41	41	42
Total	576	596	607.5
Mineral fuels	1,337	1,399	1,448
Other minerals			
Iron ore	204	237	245
Other metal ores	161	171	191
Other nonmetals	125	133	149
Total	490	541	585
Grand total[a]	2403	2536	2640

SOURCE: Ayres and Kneese [1].

[a] Excluding construction materials, stone, sand, gravel, and other minerals used for structural purposes, ballast, fillers, insulation, etc. Gangue and mine tailings are also excluded from this total. These materials account for enormous tonnages but undergo essentially no chemical change. Hence, their use is more or less tantamount to physically moving them from one location to another. If this were to be included, there is no logical reason to exclude material shifted in highway cut and fill operations, harbor dredging, land-fill, plowing, and even silt moved by rivers. Since a line must be drawn somewhere, we chose to draw it as indicated above.

materials in a volume second only to energy industries. Their production also makes the most extensive use of the physical environment and alters natural systems drastically. While many of the residuals originating from commercial agriculture are biodegradable and readily assimilated on the land from which they were originally generated, their concentration can create major environmental stresses, as do some of the residuals from pesticides and commercial fertilizer.

Commercial fertilizer use in the United States rose from an average of 22.5 million tons for the 1950–1954 period to 38.9 million tons in 1968. Its nutrient content rose even faster; nitrogen increased from 1.6 to 7.0 million tons, P_2O_5 from 2.2 to 4.7 million tons, and K_2O from 1.7 to 3.9 million tons. This represents about a tripling of nutrient content, with nitrogen increasing most rapidly. Despite the fact that U.S. fertilizer applications per acre is not high relative to other developed countries,[2] they still pose formidable problems in the effort to maintain a high quality rural environment.

To date the principal concern has been the impact of nitrogens and phosphate fertilizers on aquatic life and the eutrophication of water bodies. It also has been suggested that nitrogen fertilizer adversely affects soil structure, threatening its natural fertility by the destruction of bacteria, though little empirical evidence has been marshalled to support that contention. Both nitrogen and phosphates provide nutrients for the growth of aquatic plants. If their growth is sufficiently speeded up, the water body may acquire excessive amounts of dissolved oxygen, often followed by oxygen depletion as the food plants deteriorate. The algal bloom or profusion of aquatic weeds is the hallmark of such overnourished water and can occur from relatively small amounts of fertilizer. For example, a 1 percent loss of P_2O_5 from a one-acre field treated with 40 pounds of phosphate would support such a bloom in 5 acre feet of water. This disappearance represents a loss of about 5 cents to the farmer, probably far less than the cost modifying his cultivation or fertilizing activities to eliminate the loss. The situation is comparable for nitrogen.

In the absence of incentives to reduce loss from the field, opportunities to reduce overall application must be investigated. In earlier years, principal fertilizer losses were caused by leaching and erosion. Today most available nitrogen is taken up by plants, the actual physical removal depending upon the crop. For example, with corn the grain alone may account for only about one-half of the above-ground nitrogen content of the plant; corn removed from the field for silage removes more nitrogen than does a corn crop harvested as grain only.

The concentration of animal manure in commercial feedlots poses a parallel problem. Runoff from the lots into streams and lakes and releach-

[2] For example, in the late 1960's consumption rates in kg per hectare (2½ acres) of arable land were as follows:

	N	P_2O_5	K_2O
U.S.	30	22	18
Netherlands	357	115	138
Japan	141	102	102
U.K.	102	50	61
U.S.S.R.	11	7	8

Data assembled by Sterling Brubaker of Resources for the Future, Inc.

ing into water supplies are common occurrences, and in many rural areas water sources have been contaminated to levels far above that considered safe for domestic use. Here again the on-farm economics of the situation militate against the disposition of these manures on open fields. It simply is not economically attractive to do this and will be resisted until the environmental hazards become more generalized, more sharply defined, and chains of cause and effect more persuasively demonstrated.

Pesticides are probably the most widely recognized residual problem in contemporary U.S. agriculture. The basic advantages sought are yield increases, enhancement of crop quality and removal of the uncertainty of crop yields. For these purposes pesticides have proven effective and efficient. A recent study estimated returns of approximately $4 in farm output for each $1 spent on farm pesticides [2].

The environmental effects of pesticide use are not fully understood. Clearly many of the chemical molecules applied as pesticides have proven to be extremely persistent and have had adverse effects on the organic functioning of animals who have ingested substantial amounts through food chain concentration. There are also more immediate localized environmental effects. While the target pest population may be substantially reduced, interspecies relationships may be modified so that other insect populations flourish—an insect "bloom" analogous to the algal bloom in eutrophic waters. An individual farmer may be subject to external regional costs of pesticide use, however; his abstinence from use will not protect him from the adverse consequences of his neighbor who continues to use them. Here again the incentives are such that cumulative adverse environmental consequences may be expected in the absence of some type of regulation.

Pesticides do not present a simple problem of use or nonuse. Other options exist, and they can be fashioned specifically to address particularly troublesome pest populations. For example, biological control mechanisms (such as the sterilization of males or the use of "youth" hormones to block sexual maturation) may prove effective. Genetic protection of crops also can be developed, as in the case of the recent corn blight. Technical options of this sort are becoming more clearly articulated as we gain more knowledge in entymology and genetics. This might suggest some reallocation within the agricultural research budget. Ultimately, some policy position needs to be taken on appropriate methods for pest control.

Of the two sources of environmentally damaging residuals, fewer opportunities exist for modifying present patterns of fertilizer use than with pesticides. Under present technology there are no biological substitutes for plant nutrients.

Preservation of rural amenities

Rural environments not only provide the site and resource inputs for food and fiber production; they also provide an array of amenity services that can be directly consumed. These services have characterized American life styles throughout our history and are highly valued, although those values cannot be very precisely measured. A number of indirect indicators suggest that rural amenities hold a large and growing value to the American public, as well as to those who own a "piece of the landscape."[8] Thus an attractive and amenable physical environment in rural America is of major economic importance. Conducting agricultural affairs in such rural areas so as to preserve those amenities will constitute a significant problem during the coming decades.

The growth of demand for rural amenities suggest that public measures be taken to prevent acts that threaten to physically despoil the landscape (such as constraining strip mining activities, clear-cutting practices, etc.) and, in addition, that positive actions be taken to assure that rural landscape amenities are not monopolized by individual parties. Public land acquisition, securing of public access to private lands, and prohibitions against uses that are especially destructive of amenities are public options which might be employed for an efficient public response to the increased competition for the rival landscape and the relatively rapid growth of demand for rural amenities.

With respect to outdoor recreation opportunities, demands exist for a variety of situations—from the vacant urban lot to the wilderness area. A clearer understanding than we now have about the empirical nature of those demand functions,

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[8] It is estimated that Americans spend somewhere between $30–$50 billion yearly for travel and paraphernalia for outdoor recreation. Since 1910 national park attendance has increased about 9 percent annually and shows no sign of dampening. Data from national forests and state parks show a similar picture. Reservoir use under the supervision of the Corps of Army Engineers has increased even faster—28 percent annually during the latter part of the 1950's and early 1960's.

their interrelationships, and their sensitivity to distance, crowding, etc., is clearly in order.

Concern that recreational facilities will be inadequate in supply is perhaps most pertinent in connection with wilderness, which acquires its desirable characteristics because of light use. Long before human use threatens physical change of such an area it loses its appeal because people become aware of each other within the wilderness setting. Management measures, such as trail system design, concealment of paths, and regulating the timing of visitors, may increase the carrying capacity of any given wilderness tract—but only up to a point. There will be conflict between demands for mass and individual recreational opportunity. Conflicts also will occur between recreation use and extractive activities. The compatibility of these activities with pure wilderness recreation is very low; however, other types of outdoor recreational opportunities can be preserved if extractive activities are limited.

The mobile, affluent U.S. citizen, who over the coming decades will undoubtedly have greater leisure time, may be expected to rapidly escalate demand for rural area amenities. The details of this demand must be discovered, and a full array of rural land management options must be explored that use the devices mentioned above in various combinations and permutations.

Institutional problems

Envisaging U.S. agriculture for the next 20 years in ways that correspond to our scenario, one can discern two important areas of institutional design problems to which applied economics can make a substantial contribution. The first concerns rural communities. The farm-to-city trend of internal migration and farmer residence patterns suggest that the existing arrangements of rural communities will be inappropriate over the coming two decades.

Many local communities (villages and small towns) have shrunk to a size where they no longer constitute an effective unit for providing social services. Schools, police, sewerage, and other locally provided services have been effectively regionalized over the past two decades in many rural areas. Technologies now available for producing and delivering public services suggest that substantial efficiencies could be achieved by moving to service areas comprising several counties. The field jurisdictions of federal agencies have been organized into "regional administrative units," and federal information services have been regionalized as have various state activities. This suggests that over the coming decade we shall be evolving a system of rural community governance at a level that is larger than existing counties, yet smaller than state governments.

There are many practical questions associated with this trend to which economics can make substantial contribution. For example, we need to have explicit information about the production and cost functions of various types of public services and their distribution. Are economies of scale possible, how extensive are they, and do they imply a particular type of regional unit as more efficient than others? Unless answers to these questions are in hand we may repeat many of the inefficiencies and administrative absurdities that resulted from inappropriately delineated county systems.

The second set of institutional problems relates rather more directly to the qualitative dimension of rural resources. Aside from environmental threats associated with the use of pesticides and fertilizers, which affect virtually all of U.S. agriculture, there are a host of environmental quality issues faced by local communities. If such communities are to cope effectively with perceived environmental degradation, they must have means for discerning environmental conditions, reaching a decision on when those conditions warrant remedial action, and undertaking appropriate programs to redress environmental insult.

This represents a tall order for community institutions. It also represents a substantially different kind of institutional problem than U.S. agriculture has had to face over the past several decades. In the past most environmentally oriented agricultural organizations were offshoots of federal agencies or of national farmer organizations. The principal purpose of the former was to carry out federal policies and programs; the latter functioned primarily to influence those policies and programs. Both types of organization, however, implied that the ills of the agricultural community were susceptible to observation, diagnosis, and prescription by technical experts. The institutions and organizations at the community level were designed to faithfully and efficiently carry out programs prescribed elsewhere.

Environmental quality problems don't lend themselves to this mode of response. While they can be delineated within a generic classification, local environmental problems must be depicted in highly specific manner if a community is to

reach public choice about what it wishes to do about them. They must be perceived by parties whom existing environmental conditions affect or who would be affected by programs designed to enhance those conditions. The values a community places upon environmental degradation will determine the likelihood of a public consensus for taking remedial action, and those values must be identified.

To perform these functions community institutions must be capable of gathering and interpreting empirical information, devising alternative options for remedial action, and finally reaching community consensus about what it will do. Perhaps most important, there must be sanctioned ways of carrying out that decision, even when it entails modifying previously established patterns of community behavior. Designing the institution which effectively can serve local or regional communities in this way often is more difficult than acquiring a technical understanding of the environmental situation these communities seek to enhance.

Capital needs for efficient management of agricultural and rural environmental resources

Recent research has indicated that commercial agriculture in the United States involves substantial capital loss. Glenn Johnson and his associates have analyzed the causes and consequences of overinvestment in agricultural capital, citing this problem as a principal reason for excessive commodity production. Price fluctuations can cause marginal returns to fall below the average production costs, incurring simultaneously excessive production and capital loss (in the sense that inappropriately low returns on capital investment is being realized).

One aspect of this problem is particularly important for the management of rural environmental resources. One consequence of overinvestment is that producers tend to become "locked into" the use of existing technologies. If public policy were either to impose the environmental costs of agriculture on the farmer through charges or taxes or to prohibit the use of environmentally destructive inputs, earlier production technologies likely will be found inefficient. Should an improved technology be discovered, new capital will be needed to effect an actual substitution of technologies.

A parallel problem will be encountered, should major effort be made to adopt a population settlement pattern that provides public services to the residents of rural communities in ways compatible with a high quality physical environment. Capital is required for new ways to collect and dispose of solid waste, for water treatment technologies, and for the recycling of municipal residuals of many sorts. The dependency on new capital for an environmentally "clean" agriculture is extensive.

The question is: Will there be sufficient capital available to effect the future transitions that likely will be called for within U.S. agriculture? The answer is not at all clear. Applied economic investigations of the availability of future capital for agricultural and rural resource warrant high priority. New arrangements for financing public services also should be explored, including special governmental units which might supply rural communities with environmental protection services on a contractual basis.[4]

Traditional agricultural economics analysis of capital availability and use has been highly partial in one sense: Prices usually have been assumed to be perfectly elastic, and capital is often implicitly assumed to be endlessly available at the stated interest rate. Sensitivity to environmental matters on fronts other than agriculture has intensified the demands for capital elsewhere in the economy, and raises a spectre of critical capital shortages in the coming decade.

How Well can Agricultural Economics Respond?

Having sketched out a scenario for U.S. agriculture over the intermediate-term future and identified a series of problem clusters that are likely to assume prominence within the scenario, we must address the questions of how adequately the existing state of agricultural economics equips us to cope with these problems, and what are the principal obstacles to enhancing that capability. These questions might be asked of the teaching, research, and public service functions for which our profession traditionally has accepted responsibility.

Teaching

In many respects our profession may have greatest leverage on environmental problems confronting society through its teaching function. The success with which it handles that responsibility will determine to an important degree the

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[4] Maryland, New York, and Ohio have authorized public corporations that can operate in this way.

character, number, and effectiveness of individuals who will be coping with these problems over the next couple of decades. While the particular teaching emphasis of agricultural economics may vary among schools and departments, the profession has responsibility for providing students with (1) a general educational exposure to agriculture; (2) a training that supplements a general educational exposure with analytical competence in economics; and (3) practical experience with problem-solving groups and organizations.

The profession long has had responsibility for overseeing curricula for general students. Most often this responsibility has been carried out within the context of an agricultural college or school, and the focus has been with traditional agricultural subject matter. Today we see marked evidence of an interest by students throughout the entire university in environmental problems and rural resource conservation and allocation problems. In some instances departments of agricultural economics or colleges of agriculture have been successful in addressing this broadened educational demand. In many other instances they have not; and new departments, new divisions, and even entire colleges have been established to cover environmental resource management. I don't believe that either departments of agricultural economics or the newly established units dealing with environmental management have yet articulated a general framework within which the environmental resource subject matter can be systematically embraced in a general educational curriculum. Organizing the domain of environmental resources management is a major task for the profession, and there would appear to be sufficient academic payoff to warrant some experimentation.

The second teaching function is that of professional training in applied economics and related fields. On this point the profession deserves better grades. It has given competent instruction in standard methodologies but has not demonstrated much proclivity toward experimentation. The reason, I believe, is not lack of ability but rather a standardized concept of what a Ph.D. in agricultural economics should be and do—almost a guild tradition. Perhaps training in the analysis of environmental problems can be more efficiently and interestingly carried out through the use of pan-disciplinary workshops that demonstrate empirically the relative efficacy of different analytical procedures and methodologies by focusing on particular problem clusters.

A third component of teaching is providing students with actual experience in problem-solving situations and organizations. The utility of this adjunct to traditional professional training had been recognized in several environmental fields, and efforts are being made to fold such experience into graduate curricula either vicariously or actually. In some instances the students are required to undertake a "practicum" or internship assignment with an actual organization that is coping with economic aspects of environmental resources management and allocation. In other instances the decision-making context is provided vicariously through computer-oriented games or simulation management models which students can manipulate in searching for appropriate management strategies. Perhaps more extensive uses of these devices could be made within the graduate programs in agricultural economics.

Research

How effectively is present agricultural economic research addressing the environmental problem clusters we have identified, and what are the principal obstacles in the way of a more efficient allocation of research resources? It is very difficult to answer these questions, although I feel that the grade appropriately assigned agricultural economics departments in recent years is more B than A. Some interesting work on methodology is evolving, but with a few conspicuous exceptions agricultural economics has not in recent years made significant contributions to an extension of economic theory, and much of the empirical and applied research has been carried out within the orthodox format of production economics, marketing, trade, and development. This represents a major opportunity foregone, because agricultural economics as a discipline has unrivalled experience in empirical work, and at the present stage of the game a great deal of empirical work is needed in the environmental resources management domain. Some encouraging reorganizations are occurring within departments throughout the country, but as yet these have not produced strong track records in terms of completed research.

One of the particular research difficulties posed by environmental resources management problems is the lack of basic information. Most environmental problems posed by social scientists call for public action recommendations; yet the

technical interrelationships and functioning of the environmental systems involved are themselves relatively poorly understood. Under such circumstances short-run targets need to be set for acquiring this information, evaluating it, synthesizing it, and drawing policy interpretations.

All of this usually entails a time horizon and a research logistics plan which are difficult to carry out within a university context. The academic reward and punishment system strongly biases research effort in favor of working on shorter-run problems of a traditional genre. Often this results in defining as a total problem that which should be viewed as research contributing to a larger investigation. If universities are to successfully address this environmental domain through their research programs, I believe the existing ground rules that shape the conduct and evaluation of staff research will have to be modified. Longer time horizons must be made feasible for the individual scholar, and opportunities should be created for small groups of scholars to undertake a line of related and logically sequenced research.

Another difficulty posed by environmental problems is the multidisciplinary character of information critical to any comprehensive understanding of environmental systems. At this time I think we cannot identify any "best way" of securing the needed coordination and synchronization of related research efforts in the various social and natural science disciplines, but a case can be made for substantial experimentation. Where one sees evidence of this type of development it often is student inspired.

Public service

The public service opportunities for agricultural economics include the following:

1. To distribute knowledge gained from recent research to those who can use it.
2. To provide technical assistance to individuals dealing with environmental or agricultural processes.
3. To help local communities organize themselves so that they are capable of problem identification and can evolve a decision-making capability.
4. To provide a continuing information link between the university and local communities or state agencies.

Each of these areas needs to be addressed in the public service, or extension, arm of agricultural economics. For environmental resources management, helping communities acquire and maintain an effective decision-making capability, by providing current information to environmentally concerned organizations and agencies is perhaps the most important contribution the extension service can make to rational rural resources management.

The distinction between extension and academic members of the profession has varied among institutions, but a separate identity generally has been maintained. There is a need for closer links between extension and the teaching and research functions of the university when improved environmental quality is the objective. This is particularly true when extension serves state environmental agencies or local organizations. Closer association with the teaching function can provide students with concrete examples of how research results are translated into programs for environmental management. What is equally important, involvement with extension activities will give students an understanding of the kinds of research that can contribute to actual programs.

These programs also are useful sources of data for researchers concerned with program effectiveness. With close association between investigator and investigated, an operating agency can be viewed on a "real-time" basis. The only viable response to problems that evolve, as do those associated with environmental quality, is through agencies or other institutions that have the wit to learn from their experience and the flexibility to adapt themselves for improved performance in subsequent effort. While we know this to be so, extension efforts have not been demonstrably effective in fostering this kind of agency evolution.

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Discussion: EDNA T. LOEHMAN, University of Florida

Brewer has considered two sources of effects on the rural environment: effects internal to the rural community but external with respect to the nonrural community and external effects originating from outside the rural community. In the first category we have effects such as production of agricultural residuals; in the second, effects such as locating energy production with its accompanying air pollution in low density rural areas. Brewer feels that we need more technical knowledge, such as production functions, cost functions, biological functions, and so on, in order to deal with these problems. I do not question this, but in addition to technical knowledge we need to have more *social* knowledge since the problems of pollution are not only technical but also social.

In discussing pollution problems, besides technical knowledge Brewer does mention that policies will have to be devised in order to provide incentives to those creating externalities to change their ways. However, he does not give much attention to the problems related to selecting correct policies. This has been a major area of interest in modern welfare economics.

The question of the proper policies in the case of externalities has been dealt with at length in welfare economic literature, and negative conclusions have been reached as to the efficiency (or "first best" optimality) of most proposed policies. The choice of policy then becomes a question of the "second best." In addition the choice of policy is a social choice problem in light of the income distributional implications associated with any policy. Choosing the best policies then involves finding a common set of values and goals on which to base decision-making, as well as being able to predict the effects of proposed policies.

Other problems in the area of welfare economics discussed by Brewer are land use problems (externalities, social choice of a system of property rights), institutional problems of providing and funding public services (public goods problems), and institutional problems with respect to structuring decision-making bodies (defining a social choice function). It is clear that the study of welfare economics is quite relevant to the issues of rural environmental quality raised by Brewer. However, we cannot wait for these theoretical issues to be resolved before giving advice on policy issues.

What is the role of applied economics in this effort? First of all, as indicated by Brewer's title, we should internalize the concepts of welfare economics into our thinking, analysis, and teaching and become aware of income distribution and social choice issues as well as the traditional concerns of agricultural economics with efficiency. Second, we need to branch out into new areas of applied research in welfare economics. I shall conclude by indicating some areas of applied research in welfare economics.

Myrick Freeman has suggested a need for ex post and ex ante experiments to identify social objectives and weights. Some such experiments have been done by Haveman, Dorfman and Jacoby, Lord and others, but more are needed.

Besides experiments in social choice, controlled experiments are needed to study the effects of various policies in terms of accomplishing social goals. Brewer has also suggested this type of experiment in the case of institutional studies. Applied economists could aid in setting up and analyzing the results of such experiments.

Thus it is not just a question of whether economists can internalize environmental externalities but also whether we can be of any use in helping communities to do so. If we cannot, the study of applied economics becomes a strictly academic affair divorced from the real needs of our society.

Discussion: JOHN J. WAELTI, University of Minnesota

Dr. Brewer has converted his open-ended assignment into a useful document for discussing the agricultural economist's role in addressing environmental problems. There is little to add to his scenario of agriculture; and although some might quibble about his delineation of problem

clusters, he has identified the major areas. Therefore I shall discuss a question I consider to be of primary concern to us, namely, "How can the profession address itself to agriculturally related environmental problems?"

I agree that the profession exerts its greatest potential leverage on environmental problems through the teaching function. As one of three responsibilities in the teaching area, Brewer cites professional training in applied economics and related fields. Of fundamental importance here is the capacity of the student to distinguish between the private and the social point of view. I find that students must constantly be challenged to make this distinction and to recognize their personal biases. Agricultural students too often get little of this training. It is therefore up to us, and I question whether the profession is doing an adequate job.

Brewer notes that the profession "has not demonstrated much proclivity toward venturesome experimentation," and he is "inclined to think that the training responsibility within the domain of the environment can be more efficiently and interestingly carried out through the use of pandisciplinary workshops . . ." I caution that this effort can be successful only to the extent that the student is sufficiently grounded in basic economics. Society cannot hope to solve environmental problems without a broader-based understanding of the price system and the incentive system under which pollution occurs. A better job of teaching the principles of economics, including the operation of the price system and its limitations, is in order. Put more simply, students should be taught to understand the price system but not necessarily to worship it!

I agree with Brewer's assertion that there is a major role in research for both academic and nonprofit, nonuniversity research instutitions. In spite of the limitations of time, poor stock of information, and multidisciplinary character of environmentally related research work, I am optimistic about the contribution that economists can make. The role of university research is not so much to solve social problems as to illuminate alternatives for their solution. Research on environmental quality necessitates delineation of alternatives and logical decision processes, both of which are the heart and substance of economics. I am not as much concerned about failure of agricultural economists to advance the theory as I am about their failure to address existing problems. In particular, environmental issues raise questions of alternative patterns of resource allocation, fiscal alternatives, and regional and sectoral economic impacts of these alternatives. Although the profession has barely scratched the surface in answering these questions, the results to date have been encouraging.

Finally, regarding the all-important public service function, the economist as never before will be forced to interpret economic doctrine and research results so that they can be understood by policy-makers and by the public. The economist's reputation for inability to communicate is well-deserved. The tragedy is that we have something rational and important to say but, with rare exception, have not said it! Failure to communicate with those outside the profession will result in the world, its problems, and an increasingly skeptical taxpaying public passing us by. Accordingly, I see an expanded clientele and a greater role for extension effort in the economics of environmental quality.

Nature and Implications of Problem

CHAIRMAN: HERBERT H. STOEVENER, OREGON STATE UNIVERSITY

Discussion: KARL A. FOX, Iowa State University

I shall start from Michael Brewer's section on institutional problems and more particularly his comments on the basic social organization of rural communities: ". . . over the coming decade we shall be evolving a system of rural community governance at a level that is larger than existing counties, yet smaller than state governments."

Deteriorating environmental quality of large metropolitan areas lends support to a strategy of fostering alternative growth centers as a means of accomplishing population redistribution. Such redistribution will cause many small cities to grow larger, but presumably not so large as to create high levels of traffic congestion and environmental pollution for their residents. Nevertheless, the pressures of larger populations will be felt throughout the commuting, shopping, and recreational fields of each alternative growth center, and provisions must be made for anticipating and dealing with these pressures.

Most promising alternative growth center is the central city (regional capital) of each functional economic area (FEA). The FEA in nonmetropolitan areas is a cluster of contiguous whole counties approximating the home-to-work commuting field of its central city; the major retail trade and service area of the central city also approximates its commuting field. An FEA is essentially a low-density city in terms of the economic and social interactions that take place within its boundaries, but it lacks political organization. A logical implication of this insight would be to extend municipal powers to governing bodies elected on an FEA basis. Some powers would be passed upward to the FEA level from counties and municipalities; other powers would be passed downward to the FEA level from the states. Field offices of state agencies would be located in some or all of the FEA central cities; counties would constitute acceptable subareas for the administration of some FEA programs.

An FEA-level municipal government could internalize many of the externalities of public service systems that are now organized on an individual town or county basis. All environmental protection services relevant to the area could be concentrated in a single department of the FEA government. Whatever pride residents of a small city now take in the appearance and amenities of their immediate surroundings could be extended to the FEA as a whole. A large share of the total problem of environmental protection would be solved if the government of each FEA administered the relevant programs in the best interests of its own residents. The best interests of the residents of one FEA considered as a separate optimizing unit might involve too much runoff of agricultural chemicals and animal or human wastes from the standpoint of FEA's downstream. A state environmental protection agency would have the task of internalizing such externalities within its borders and/or in cooperation with neighboring states.

The establishment of general purpose FEA-level governments may encounter opposition in the short run. This would not preclude the organization of state environmental protection services using FEA's as planning, reporting, and administrative units. In Iowa, extension service field offices, community colleges, and area vocational-technical schools are organized on an FEA basis; each system moved according to its own logic. Some other systems have moved to this basis or are considering doing so. Implementation of an alternative growth centers strategy would intensify the need for organizing environmental protection services on an FEA basis.

Discussion: E. R. SWANSON AND W. D. SEITZ, University of Illinois

THE search for methods of internalizing environmental externalities must include identification of (1) the technical means for internalization and (2) the persons or groups who may hold expectations of gain, in some sense, from such internalization. Expectation of gains is an important ingredient in the incentive system needed to bring any plan into reality. Agricultural economists have a potential role in this process by analyzing the economic incentives under various institutional designs. As mentioned by Brewer, local institutions that are effective in

addressing environmental problems must facilitate dialogue between affected parties and expose the options for community action. In this discussion we illustrate the initiative that can be taken by local institutions with a project that combines land reclamation with sludge disposal from Chicago.

Environmental externalities from strip mining include damage to the beauty of the landscape and those from sludge disposal may include air pollution if incineration is practiced. Three parties may be identified as direct participants in the project: Fulton County Board of Supervisors, Metropolitan Sanitary District of Greater Chicago (MSDGC), and the mine operators. Basically, Fulton County desires an increased tax base and economic activity, MSDGC must find an alternative method for sludge disposal, and the mine operators must comply with the laws on reclamation.

The Fulton county planning administrator initiated contact with MSGCD and a land-reclamation sludge-disposal plan has now been jointly developed. The organizational structure of Fulton county government was capable of responding to the perceived set of problems largely because of the county planning commission and its full-time planning administrator. The commission encouraged communication among the interested parties, including the county board of supervisors.

Under the proposed plan Fulton County will lease strip-mined land from the mine operators and then sublease the land to MSDGC who will level the land and apply the sludge. The final decision on adoption of the plan has been delayed until evaluation of levelling and application of sludge on a 7000-acre tract purchased by MSDGC. Economic analysis of potential gains to each of the participating parties will be an important element in acceptance of the proposal.

Discussion: C. V. MOORE, FPED-ERS-USDA, Davis, California

Do agricultural externalities need to be internalized? This question implies three subsidiary questions: When have we in fact internalized an externality? What happens when we do? What happens if we don't? Two California studies may shed some light on these questions, but first internalization must be defined. Under a strict interpretation, an externality has been internalized when the costs of an injury to other parties due to an act of a firm appear in the private cost function of that firm.

In a study of the increasing salt content in the lower Colorado, a damage function was estimated relating agricultural income in the Imperial Valley of California to the projected salt concentration in the river due to upstream development. A salinity of 1210 p.p.m. total dissolved salts has been projected by 1990, an increase of 280 p.p.m. over the current average of 930 p.p.m. The average annual decrease in regional agricultural income for each 100 p.p.m. increase in salts is estimated to be $1.6 billion. It has been argued elsewhere that this is an external diseconomy attributed to additional upstream development. Further, these downstream costs should be internalized by the development agencies by including them as a cost in their benefit-cost ratios. However, this does not satisfy the strict criterion for internalization set out earlier because the costs are not included in the private cost function of the firm making the decision to irrigate. Also, some will argue that the initial decision-maker is the development agency and internalization is completed if the costs are included as social costs in the feasibility calculation and an ability to compensate or to pay a bribe is shown.

If development agencies and newly irrigated farms are required to include these costs in their private costs, this may change the decision on whether to proceed with the project. If the externality was not internalized, income would be redistributed away from the downstream users and to the land owners in the new project.

The second illustration refers to the injuries attributed to organic phosphate pesticides. The first question is where does one start counting? If a pesticide manufacturing worker is poisoned, is this an externality? How about the worker in pest control application—if he is injured, is this an externality? If a seasonal fruit picker is injured by pesticide residues, is this an externality? For the question when has the externality been internalized, is carrying workman's compensation and general liability insurance a sufficient condi-

tion? Workman's Compensation in California covers all medical bills but lost wages only if six or more days of work are missed. It does not compensate for the pain and misery of vomiting, nausea, or dizziness associated with pesticide poisoning. In a California study, only 6 percent of a sample of farm workers reporting pesticide poisoning symptoms indicated their medical bills were paid by Workman's Compensation. This would indicate that the state's internalizing institution has not achieved expectations and that a very high percentage of these costs were transferred to the farm worker or the general taxpayer of the county through the welfare system.

Approaches to Solutions

CHAIRMAN: JOSEPH C. HEADLEY, UNIVERSITY OF MISSOURI

Discussion: W. H. LUCKMANN, Illinois Natural History Survey and Illinois Agricultural Experiment Station

I AM certain that we have the technical ability to meet and solve the problem of pesticides and environmental quality and to guarantee a viable agriculture and a viable environment. From the biological standpoint there are two major emphasis areas for research. The first deals with residues and hazards and, specifically, the fate and effect of pesticides in the environment and the development of all-new, safer compounds. Persistence, transfer, magnification, and storage—the food chain story—can now be accurately determined for any biologically active compound in highly reproducible laboratory aquatic ecosystems. These model ecosystems, structured in various ways with *Daphnia*, snails, fishes, and algae as major components, are as sophisticated as any precision electronic equipment.

The recent development of a high potency and stable preparation of *Bacillus thuringiensis* (a pathogen of lepidopterous larvae) and an all-new biodegradable DDT are a direct response to this emphasis area. Old compounds reconstructed (the new DDT), new formulations of old products (the new *Bacillus thuringiensis*), and increased research on less hazardous analogues of old compounds offer vast possibilities for solutions to the problem of residue and hazard.

The second emphasis area is the development of pest management systems. The adverse environmental events of the DDT era are now historical record, and this record is perhaps our most valuable guideline for development of these systems. Pest resistance, pest resurgence, elevation of secondary pests to primary pest status, and reduction of predators, parasites, and competitors are all recognizable features of long-term, single-factor control programs based solely on the use of pesticides. Continued sole dependence on pesticides, even the all-new, safer ones, could lead to problems similar to those experienced during the past two decades. Pest management is a deliberate, conscientious attempt to blend and harmonize the different techniques making up a control system. Insecticides are important tools in management systems. From the standpoint of agriculture and the environment, pest management systems can best be developed by the team approach to several large complex problems having maximum environmental impact and social and economic involvement. Most important of these to Illinois and the Midwest are the insects-soil-corn complex and the weeds-soil-corn-and-soybean complex. These two emphasis areas affect nearly the entire Cornbelt of the United States and involve regular applications of insecticides and herbicides on 50,000,000 or more acres of farm land.

An important step in developing pest management programs is the construction of crop life/mortality tables, which require a complete inventory of the planting at the beginning of each main growth period of the crop. Mortality records are taken every few days throughout the growing season, together with measurements of the major independent variables and yield. Such interdisciplinary studies will lead to the development of realistic crop production models that will provide an in-depth view of the management system, the economics of it, and the processes that govern numerical trends.

The agro-ecosystem, viewed by most laymen and ecologists as an annual monoculture, is in reality a blend of diverse species, including perennials. The relationship of pests, predators, and parasites between two or more crops offers promise of pest management on a truly large scale, and such programs extend beyond the site problem to encompass county, state, and region.

Discussion: A. ALLAN SCHMID, Michigan State University

Can economics internalize environmental externalities? Theory suggests that if ownership is determined the market will eliminate Pareto-relevant externalities. The amount of total externality that is Pareto-relevant depends on transaction costs (and effective demand). This theory leads some to concentrate research on how to get all products owned and traded at low cost. It

leads to suggestion of a river basin commission selling waste assimilation capacity to feedlots, etc. There would be no Pareto-relevant externalities since each user, including fishermen or their public representatives, would make a bid according to his relative demands. Some fish will be killed or some beef eater left hungry. Internalization doesn't promise nirvana—just efficiency. Someone will still be exposed to costs of interdependency (and scarcity), and theory suggests nothing as to who this someone should be. Our language of Pareto-irrelevancy almost suggests that this is irrelevant for scientific investigation.

Beware of theory which suggests that everyone gains when every product has a price—any price —collected by anyone, because this system is Pareto-efficient. When stream standards are set it is easy to see that it allows for certain users and not others. This is a difficult distributional decision. Can we escape this conscience-troubling choice by letting some public authority sell the use right to the highest bidder? Alas, barriers block escape. The prior distribution of wealth influences who is the successful bidder. Also, we must decide just who is this public that collects rent. If a farmer buys stream capacity, shall the revenue be used for fish habitat elsewhere or go to the state or federal general treasury? Some say that this is *just* a matter of income distribution and the question of efficient resource allocation is unaffected. I prefer to reverse it. Whether something is owned and marketed is *just* a matter of Pareto-efficiency, and the important issue of property ownership and income distribution is untouched. Out of the large number of efficient solutions, which shall we choose?

Do the rich get trout fishing and white water canoeing, or are these resources truly public property with revenues from their sale available also for schools and housing? Internalization of externalities provides no answer. Income distribution affects demand. Yet when analyzing alternative distributions of ownership we often posit the demand schedules and separate resource allocation from distribution. Design of social institutions is not just to insure that the competition over whether agriculture or fishermen get to use resources is reflective of relative demand schedules, but also what affects these demand curves. Before people instruct public representatives on institutional choice, economists must trace out how distribution affects demand and productivity.

What is the economics of changing property distribution over time? Does a given change require compensation? Why is zoning that reallocates values a police power, while a modification of riparian rights is commonly regarded as a compensable taking? Instead of becoming trapped in the beguiling mesh of the Pareto-better criterion or legal semantics, I urge research into the actual consequence for human behavior of given property-right redistribution. How much uncertainty of rights change can entrepreneurs handle before it destroys long-term investments? What are the consequences of the use of market power which also destroys asset values? Is the source of change critical, or just the size?

There are many economic solutions to the environmental problem, but who gets to define *the* problem? I believe that the country is in danger of social upheaval and that the big issue is property distribution and participation in control. This will not be solved even if we get everything owned and traded with zero transaction costs.

Discussion: JAMES H. SARGENT, Environmental Protection Agency

Because agricultural waste is less susceptible to treatment, legal solutions to its control must be considered in terms of their ability to prevent or minimize polluting effects rather than to insure an after-the-fact cleanup of the pollution created.

The common law, traditional form of legal redress, while still having value for the individual litigant, does not constitute a systematic, publically oriented comprehensive program.

In regulation and enforcement systems, now virtually the sole approach to pollution control, the control agency determines how much pollution may be discharged and what standards must be maintained in receiving wastes, conveys this information to the polluter in the form of effluent criteria and water quality standards, and uses its authority to punish a discharger if he fails to comply. The Federal Water Pollution Control Act, as amended, because its enforcement authority is premised on identifying and measuring a discharge, does not apply to typical agricultural pollution problems. The Refuse Act Permit Program will apply to certain confined feeding operations but not to agricultural runoff or irrigation return flow.

Regional (river basin) and state pollution control agencies have not realized their potential. Regional agencies, which could deal logically with interstate problems, have traditionally been underfunded and lacking in enforcement authority; state agencies have not put enough emphasis on receiving waters criteria and on long-range planning. The regional approach represents an opportunity for the agricultural community to voluntarily control its own pollution, utilizing existing farm-oriented groups organized on a river basin or irrigation district basis.

Federal regulation of pesticides has not heretofore regulated the use of pesticides, having concentrated on registration and labeling. A new bill being considered by the House Agriculture Committee would classify pesticides into two categories: restricted use and general use, the former to be used only under supervision of a certified pesticides applicator licensed by the state according to standards set by the E.P.A. The bill would make it unlawful for any person to apply a pesticide other than in accordance with the labeling instructions. Civil and criminal penalties and injunctive authority are provided.

If the new pesticides regulation proves workable, perhaps the concept of control of use could be applied, either externally by a pollution control agency or internally by some self-imposed standards, to fertilizers. Another possibility, if agricultural technology ever advances to the point where runoff or irrigation return flow can be captured and controlled, is recapture of nutrients and treating return flow to decrease salinity, thus furthering the ultimate goal of recycling resources. Yet another option would be to develop effluent criteria for pesticides and apply them to the discharge of runoff or irrigation return flow.

Tax incentives may have value on a short-term basis to soften the economic blow of compliance. Effluent charges involve the pollution control agency planning, locating, and building all pollution control faciliites on a river basin under a master plan to maximize water quality. Financing is obtained by levying a fee against each contributor of pollutants based on the quality of his effluent. Such a system may be applicable to agriculture by computing the fee on the basis of the amount of fertilizer applied. This would create a profit incentive to optimize the use of fertilizers.

Contributed Papers
(Abstracts)

CHAIRMAN: MAX LANGHAM, UNIVERSITY OF FLORIDA

An Economic-Ecologic Model for Evaluating the Environmental Repercussions of Area Development

JAMES C. HITE, CLEMSON UNIVERSITY, AND
EUGENE A. LAURENT, GEORGIA INSTITUTE OF TECHNOLOGY

THE acquisition of new industry has been the major goal of many rural areas in the United States in the years since World War II. Faced with rapid mechanization of agriculture and decline in farm influence, many areas have ignored the environmental costs associated with industrial development and have welcomed any and all industrial prospects. In the late 1960's, however, came a noticeable shift in emphasis; acquisition of industry began to be viewed as a mixed blessing, and local leaders began to be questioned often about the environmental consequences of particular types of areas in economic growth. Industrial development groups found themselves hard-pressed to answer many environmental questions. Techniques for quantifying the trade-offs between area economic growth and environmental quality are needed if planners and public administrators are to respond to these questions and identify the paths of developments that will do minimum environmental damage.

One possible approach to analysis of the environmental repercussion of area economic development is modification of the basic static Leontief model. Such a model can be structured to show not only interindustry transactions, but also intersystem flows between an area economy and the local ecosystem. The model contains two basic elements: (1) the Leontief inverse of an area input-output matrix and (2) an environmental matrix containing data on resource use or residual emission per dollar of gross output for each sector in the input-output matrix. Operational implementation of the model is achieved by post-multiplying the environmental matrix by the Leontief inverse. The results show both the direct and indirect effects on resource use and residual emission resulting from specified types of area economic development.

Empirical implementation of an economic-ecologic model for the three-county Charleston (S.C.) metropolitan area and the Beaufort County (S.C.) area reveals that all the economic sectors in the area, directly and indirectly, produce residuals that are potential pollutants of the natural environment. The economic-ecologic linkages are far more complex and far-reaching than the direct and easily identifiable linkages would indicate, and the cumulative environmental impact of those sectors only indirectly linked to the ecosystem is quite significant. Furthermore, the two case studies show that development which produces relatively few environmental problems and major economic benefits in one area may produce major environmental problems and few economic benefits in another area, even though the size of the particular development is the same in both areas.

The Leontief model is a linear system; as such it uses constant coefficients that introduce a measure of error into the estimates which can be obtained. Moreover, when modified to include an environmental matrix, the system is quite sensitive to the level of aggregation in the industrial sectors. The waste residuals of a dairy food processing plant are quite different from those of a bakery; if both activities are grouped under "Food Processing," gross errors of estimate may result. Yet, when used with care, an economic-ecological model based on the Leontief framework provides a basis for calculating the trade-offs between area economic growth and environmental quality and thus adds a missing dimension to the information available to public officials charged with fostering area development within environmental constraints.

Market Solutions to Externality Problems: Theory and Practice

Alan Randall, New Mexico State University

Economists recognize at least three broad classes of methods of solution of externality problems: (1) market solutions, following establishment of a liability rule to serve as a starting point for negotiations; (2) systems of fines, charges, taxes, or subsidies; and (3) systems of standards, backed up by threat of fines or jail sentences for the disobedient. It is noticeable that economists tend to prefer solutions in categories (1) and (2); and there is a group of academic economists who remain fervent supporters of (1), while politicians, administrators, and the general public seem to have more faith in (3).

Market solutions to externality problems rely on the self-interest of the involved parties to ensure realization of the potential gains from trade that characterize a Pareto-relevant externality. As always, efficient exchange requires precisely defined and rigidly enforced property rights. With external diseconomies these property rights include some specification of the laws of liability for damages. Two extreme examples of such liability rules are the zero liability rule and the full liability rule; a continuum of intermediate liability rules could be conceived. The zero liability rule specifies that damage may be caused with impunity; under such a rule the affected party has the incentive to offer a bribe to induce the acting party to reduce his output of external diseconomy. The full liability rule specifies that absolutely no damage may be caused without the consent of the affected party; under such a rule the acting party would have an incentive to offer compensation to induce the affected party to accept a positive amount of externality.

Market solutions are attractive to economists because they leave the setting of both the acceptable amount of externality and the charge or subsidy to the "invisible hand" and thus promise Pareto-efficient solutions, given the generous assumptions of competitive microeconomic theory. Under R. H. Coase's influence [1], the belief spread that the final market solution to a particular externality problem is allocatively neutral to the particular liability rule in operation; choice of liability rule may be made after consideration of a single variable, income distribution. However, Dolbear [3], Mishan [4], and Randall [5, 6] have effectively demolished this claim at the theoretical level. Allocative neutrality occurs only where no consumers are involved, capital is a free good, and transactions costs are zero. In other situations a full liability rule will result in (1) a higher degree of pollution abatement and (2) fewer and higher-priced commodities than a zero liability rule. Crocker [2], in an empirical case study, has reached a similar conclusion.

If a greater degree of protection of environmental quality is desired, a general conversion to the full liability rule or something approaching it seems necessary before market solutions can be relied upon to do the job. Even then the superiority of market solutions to other solution methods cannot be assumed without empirical study of the relative transactions costs of the various solution methods.

In the complete paper, of which this is an abstract, some observations are made on the functioning of market solutions under a full liability rule.

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Economic Implications of Some Citizen-Initiated Legal Mechanisms for Solving Environmental Quality Problems

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The individual may feel powerless when confronted with the complexity of solving problems of pollution. But it may be possible for a private citizen (or group) to have significant influence through court action initiated against polluters or public agencies that do not carry out their responsibilities.

Common law provisions such as nuisance, trespass, and water rights provide legal bases for suits against polluters. Generally the individual must have been damaged in some way to use those remedies. Nuisance actions have been used more often and more successfully than the other two. Such suits generally seek damages and/or an injunction. However, a balancing-of-interests approach is used by many courts, and since the polluters may have substantial financial interests they are allowed to continue operating. A trend is to require modifications in the plant to reduce or eliminate the pollution.

Statutory and constitutional provisions also provide bases for legal actions. Class actions may be used where the interest of an individual is too small to justify action, although there is no clear precedent in the pollution area for their use. Declaratory judgment actions under the Federal Declaratory Judgment Act or, in many states, under the Uniform Declaratory Judgment Act may be used to ask the courts to determine whether a specific agency action is valid or, in some cases, to go directly against the polluter.

The Refuse Act of 1899 prohibits pollution of navigable waters and allows those who provide information to share in the fines. Generally, when an informer shares a statutory penalty, this provides the basis for a *qui tam* action, i.e., the individual can initiate an essentially criminal action against the polluter. Since the Refuse Act does not prohibit *qui tam* actions, it is felt that they are permissible. The National Environmental Policy Act of 1969 has many provisions designed to protect the environment, including a requirement that all federal agencies consider the effects on the environment of any proposed action and that a written report be made. Although the courts have refused to interfere with administrative decisions, they have required that the procedural requirements of the law be met.

Other approaches suggested include the idea of a constitutional guarantee to a clean environment under the unenumerated rights retained by the people plus the due process clause, under the 5th and 14th amendments. It also is thought that the public trust doctrine may be used to protect lakes, rivers, seashores, parks, and other land which can be considered to be held in trust for the public rather than for the interests of private parties.

A procedural constraint that has hampered action by persons interested in the environment but not directly affected is the requirement of standing to sue, i.e., that the individual have a personal stake in the outcome. Recent court cases in the environmental area appear to have relaxed this requirement, but conflicting decisions continue to cloud the issue.

While legal actions by individuals are not *the* solution to environmental decay, they can be useful to (1) internalize some of the external costs through damages and fines (or induce firms to reduce pollution to avoid such costs), (2) require public agencies to meet their responsibilities, (3) produce pressure for a more adequate and rational approach to the problem, and (4) halt or delay some of the worst abuses.

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Measuring the Impacts of Solid Waste Disposal Site Location on Property Values

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THE large and growing quantity of solid wastes poses an increasingly complex disposal problem for rural and urban areas. One important effect of the location of disposal sites is the external effect on adjacent property values. This paper attempts to estimate external effects on property prices resulting from the location of landfill types of solid waste disposal sites. This has important implications for public policy on site location and possible compensation to internalize the resultant external effects.

A single equation linear regression model for price estimation is hypothesized. The data sample is 182 observations of single-unit house sales over the period 1962–1970 in the neighborhoods around five solid waste disposal sites in Fort Wayne, Indiana. Date and price of sale, as well as location of the property and detailed information about dwelling characteristics, were obtained.

Three general categories of predetermined variables are used: (1) Physical attributes of residential property—size of house and lot, number of bathrooms and bedrooms, age of house, amount of encumbrance and ownership-tenant occupancy (the key features of the quantity and quality of living service provided by a piece of residential property); (2) year of sale—the best available measure of the general level of cost of housing; (3) factors representing amenities and disamenities associated with solid waste disposal sites and neighborhood characteristics. Based on a diffusion phenomenon, the impacts of solid waste disposal sites on residential property prices were measured by distance from the nearest disposal site and the absolute degrees that the residential property is away from downwind (prevailing) of the disposal site. Zero-one variables were used to represent differences among disposal sites.

The predetermined variables in the linear model explained approximately 78 percent of the variation in residential property prices. Coefficients of the physical attribute variables were all significantly different from zero at the .05 level and all had the hypothesized sign except the number of bedrooms. The distance and angle variables are key policy variables in the model. Both coefficients were positive as hypothesized, suggesting that a premium is placed on being a greater distance away and being away from downwind of disposal sites. The estimated coefficients indicate that on the average the price of residential property increases 61 cents per foot of distance and $10.30 per degree away from downwind of a disposal site.

This first attempt to measure external effects of solid waste disposal sites on adjacent property values has important implications for community development and policy. The empirical results suggest magnitudes of costs imposed and indicate the nature of their distribution around solid waste disposal sites. In decisions concerning disposal site location, external social cost and benefits are an integral and possibly major factor. Further research is therefore warranted in refining the model and its variables to more accurately measure these effects.

PROGRAM ORGANIZER: W. NEILL SCHALLER, FARM FOUNDATION

Impacts of the Changing Economic and Social Environment on Managers of Agricultural Firms*

WILFRED CANDLER

Introduction

IN inviting me to prepare this seminar paper, Neill Schaller specified that the program organizers were thinking in particular of changes in the organization and control of the food and fiber system, changes in the sources of public pressure and policies, and the impact of management information systems. The organizers hoped that the seminar could zero in on the meaning of these forces for managers—their adjustment problems, requirements, and future prospects.

In preparing this paper I have chosen a wide definition of manager to include government and college staffs as well as corporate managers,[1] farmers, and other sole proprietors.

Specific changes affecting these managers include:

(1) The increase in size of organization due to merger and conglomeration.

(2) The tendency towards larger production units.

(3) The changing attitude towards business and consumerism.

(4) The increasing distinction between commercial farmers (where the production is) and noncommercial farmers (where the people are).

(5) The ubiquitous impact of the computer.

(6) The changing political power of agriculture.

As I listened to the helpful comments of my colleagues on an earlier draft of this paper,[2] I decided to put major emphasis on the impact of the computer and the increasing division of farmers into commercial and noncommercial. If this results in a badly biased paper, I am confident that the discussants will restore our perspective.

The Computer and Middle Management

Typically the initial impact of the computer on a company is felt in the accounting and operations research functions. The accounting department's function is unaffected by the computer, although methods of operation may be changed (for example, a shift to fully numeric coding of expenses and revenues) and the staff profile will usually be altered. While the computer is confined to accounting and the staff functions of the operations research department, its impact on the overall operation of the firm remains relatively small. Some strategic decisions may be affected in the light of staff studies of alternative investment opportunities, but by definition daily tactical decision-making in the firm remains unaffected.

A subsequent, and much more important, impact of the computer occurs when it becomes incorporated in routine day-to-day line decision-making. At the simplest level this may occur in the raw material mixing types of decisions where the nutritionist is responsible for specifying ration requirements, but the computer selects the least-cost feed formulation consistent with these requirements. If the nutritionist previously had been responsible for actual ration formulation, *this change involves the shift of a decision-making function from the nutritionist to the computer.* This use of the computer in the day-to-day management of a firm is still relatively rare, but where computer profit planning and control have

* Journal Paper 4545, Purdue Agricultural Experiment Station. The research reported in this paper was carried out under Project 1595. Constructive criticism of an earlier draft of this paper by Bob Acton, Em Babb, Paul Faris, Ron Knutson, and Bob Schneidau is gratefully acknowledged.

[1] *All* of these may be described as bureaucratic managers in the sense of operating in an organization characterized by: (a) a division of labor based on functional specialization; (b) a well-defined hierarchy of authority; (c) A system of rules covering the rights and duties of the incumbents; (d) impersonality of interpersonal relations; (e) a system of procedures for dealing with work situations; (f) Promotion and selection based on technical competence [3, p. 32].

[2] Particularly the mordant comment of Paul Farris "The useful part of this (20-page) draft starts at the bottom of page 8 and ends at the top of page 11."(!)

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een made a part of the operating managerial eam its impact can only be described as revoluionary. By "a part of the operating managerial eam," I mean operating decisions such as: Which pork cuts to put in a sausage mix? Which ruck to send to which retail outlets? Which fuures contract to buy or sell? Which elevator to ise to meet a grain delivery commitment? In each of these cases a decision to take action has een made, and the computer is used to ensure hat the action is implemented in a least-cost (most-profit) manner in the light of available information.

This use of the computer has major impact:

First, it typically reduces total costs (increases otal revenue) by from .5 to 2.5 percent, which loes not appear too spectacular.[3] If, however, the irm is making only 2.5 percent profit on turnover, this represents a 20–100 percent boost in net profit.

Second, the computer typically provides shadow prices, or marginal costs, for existing and alternative activities, so that management can dentify the really profitable purchases or sales and go after them. The theoretical efficiency of a free market economy rests, *inter alia,* on the assumption that the participants *know what they are doing*. It is only with the advent of computer-assisted management that this assumption is beginning to be fulfilled. *Thus better internal managerial control by firms should also result in better market performance.*[4]

Third, a totally new emphasis comes to be placed on the prediction of price, demand, and supply. In the traditional managerial situation the firm could not make an optimum decision on the basis of given information. With a proven computer analysis, however, and confidence that the best decision will be made in the light of existing information, prediction becomes the name of the game. Last digit accuracy is still not important, but improved prediction can be transformed easily into improved decisions.

Fourth, management is afforded the opportunity to look at the broader issues of company policy. Given that order has been established in one aspect of the company's operations, this order has a way of spreading. The company that knows it is optimizing its day-to-day manufacturing decisions is provided with a base from which it can hope to optimize its week-to-week inventory policy, and subsequently its annual sales strategy. Indeed the search for order which follows from computer management assistance may provide a major motive for integration. If the firm finds that it has certain raw material requirements (or market share needs) that cannot be reliably met on the free market, it has an immediate motive for integration.

Fifth, this development greatly simplifies research into the affected aspects of managerial behavior. Instead of a behavioral model of managerial action, if he has access to the correct coefficients and model structure[5] the researcher can use the appropriate computer model as an *exact* model of the operations of the firm. This can then be used to study the affects of a variety of external stimuli.

Sixth, though the return over variable costs for these computer aids to managerial decision-making are normally extremely high, the fixed cost of developing and installing the program is also high. These programs themselves, then, are a factor contributing to economies of size.

There are very many middle-management functions to which the computer can be applied; and its capacity to make *all* consequent adjustments for a decision gives it an inevitable advantage for the handling of routine decisions.

Let us take the example of inventory control for a farm machinery company. When a farmer rings a dealer for a replacement part and this request is entered into a computer system, it is immediately possible (a) to know whether the part is in stock at the dealers; (b) if it is not in stock, to know where the cheapest and/or quickest available source for the part is; (c) to order and confirm shipment; (d) to adjust the manufac-

[3] See, for instance, reports of profit improvement on gross sales of 1.6 percent in ice cream manufacture [6], 2 percent in meat packing [8], and 84 cents per ton for plant-wide feed formulation, rather than feed by feed "least-cost" formulation [2].

[4] Good market performance still requires competitive behavior by other firms in the market. There is no doubt that the computer can also provide guides for "implicit collusion." Given estimates of price elasticity in a market, individual suppliers can calculate the price level at which gross revenue for all suppliers would be a maximum; this might in turn suggest less aggressive pricing policies than would be pursued if this information were not available, especially if other firms in the market are known to have the same type of analysis available to them.

[5] Access to the correct coefficients and model structure is of course not likely to be easily available. However, even representative coefficients would permit a detailed quantitative study of decisions which could otherwise be studied only qualitatively or on the basis of aggregative estimates.

turing schedule for this part; (e) to modify projections of optimum inventory levels by time period; and to do all of the above in some least-cost fashion.

Obviously, these same actions could be taken without the computer, but the time taken and phone calls required to assemble and distribute the relevant information would be prohibitive. This costly human activity can be replaced by one central analysis by the computer, with transmission of results when the analysis is completed.

The computer can also be used to provide initial price and quantity estimates. Provision can be made for managerial input to modify these projections for factors not in the computer model. This gives the computer responsibility for formulating "ball park" estimates, with provision for "fine tuning" by management. Again, this is an example of the computer displacing human decision-making for the more routine type of managerial responsibility.

This impact of the computer affects not only the efficiency of production and marketing, but also seriously affects managerial job specifications. The ability of the computer to make routine management decisions in some optimal manner has huge implications for the middle managers. For example, the man who used to be responsible for locating and ordering a replacement part, and possibly changing inventory policies, now simply has to transfer the farmer's request to the computer and transfer the computer's analysis back to the farmer. Obviously there is the potential here for the spare parts manager to be transformed from a real decision-maker into a glorified clerk.

The same loss of responsibility can be seen for nutritionists who used to be responsible for ration formulation and now have this function performed by the computer. There is a loss of responsibility by the transportation manager when the computer decides how to schedule trucks. There is a loss by the production manager when the computer decides sequence of jobs to be performed and length of production run. There is a loss by the sales manager when the computer decides the minimum price to be quoted for a sale; and the procurement manager loses responsibility when the computer decides the maximum bid to be made for additional raw material; and so on.

The systematization of managerial decisions by the use of optimizing (or near-optimizing) computer models implies a split of middle-management responsibilities. On the one hand, many managerial positions tend to be robbed of their decision-making content and the manager becomes a glorified clerk responsible only for implementing computer decisions; on the other hand, a smaller number of positions have their decision-making content enhanced. For these positions, instead of asking "What should we do now?" the questions become "What do we want to achieve?" and "What information do we need?" (in order that the computer can decide what to do now). In addition, a new and sophisticated set of managerial tasks are being created in the programming of computers to carry out middle-management decision-making. The skills needed for these new tasks include computer programming, quantitative model building, and problem analysis of a high order. The proportion of existing middle management who can be successfully retrained for these new positions is low.

This trend, which we are now observing, was predicted as early as 1959 by Leavitt and Whisler in a stimulating paper [7]. Middle managers who are making decisions today in the same way, using the same classes of information they used yesterday, are vulnerable to having their decision responsibility usurped by the computer, leaving them with the much lower grade responsibility of implementing the computer's decisions. This is not to say that all such managerial positions will be replaced in the near future, but it is to say that this trend exists.

One reason that replacement will take time is the analytical/programming investment required to allow the computer to make optimum decisions. Computerization is not necessarily immediately synonomous with simplification. It may, for instance, involve transfer from alphabetic to numeric identification of items, with almost endless opportunities for confusion, until the new system has been learned by all concerned; or it may demand the assembly of information unused in human decision-making. The change is made by ad hoc groups of operations research people and people familiar with the technology and implications of the decision being automated. These loosely formed groups disband once an operational program has been developed, to regroup in other combinations around the next decision-making area to be computerized.

A result of the automation of routine decision-making is likely to be a trend towards centralization of control, certainly a trend towards increased power by top management. It is ironic that Galbraith should have alerted us to the

power of the technostructure just as this power began to decline.

If the traditional type of middle manager in bureaucratic organizations has problems of technological obsolescence,[6] so does the traditional type of sole proprietor, especially farmers classified as noncommercial producers.

Economies of Size and the Farmer

The importance and growth of large farming units was discussed last year by Krause and Kyle [5]. They pointed out that large farms (over $100,000 gross receipts) had increased from 1959 to 1964 at the rate of 10 percent per year, while very large farms (over $1,000,000 gross receipts) had increased in excess of 20 percent per year in the same period. As Krause and Kyle point out, the growth of these very large farms raises important questions for agricultural policy, but from an organizational viewpoint they are just another bureaucratic organization.

Many of the large farms ($100,000 of gross receipts), however, represent the upper end of commercial family farm operations with a sole proprietorship, partnership, or tightly held family corporation. Krause and Kyle argued that when account is taken of marketing economies (both purchase and sales) and the opportunity to spread the overhead on machinery, average total cost continues to decline beyond the size limit of current family farms. They presented illustrative figures to show (with constant technology) a cost reduction of $5 per acre as a midwest corn farm increased from 500 to 1000 acres of corn and a further reduction of $2 per acre as it increased to 5000 acres.[7]

Our experience in budgeting midwest cropping enterprises at Purdue confirms these findings. Repeatedly, the farmer-supplied figures suggest either (a) the farmer should buy larger equipment to improve the timeliness of his operations, or (b) he should rent more land to improve the utilization of the equipment he already has. In either case, the figures suggest that increasing the size of the farm operation would be profitable. Thus the changing economies of size in most lines of agricultural production mean that some form of expansion, for those able to do so, is almost always preferable to a reduction of indebtedness.

At least some portion of these economies of size should be attributed to experiment station research and cooperative extension. In discussing research and extension emphasis it has frequently been argued that "our job is to increase production. Therefore we should work with the larger farmers who, by definition, are responsible for a larger proportion of production." A "trickle-down" effect is often relied upon to pass on technical improvements first proven with the larger farmers to their smaller neighbors.[8] Where practiced, this emphasis by extension people on working with the larger producers would itself contribute to economies of size in farming.

For successful expanding farmers there is a problem of loss of managerial control.[9] This is obvious when expansion is achieved at the expense of integration, and the farmer may find himself the owner of a large business in which he is little more than laborer. A more subtle loss of managerial control is threatened by the introduction to farming of computer assistance with routine managerial decisions. This has been discussed already in the context of bureaucratic organizations, but similar developments are likely for large-scale farmers. We already have computer programs designed to assist in the management of cattle feedlots and broiler enterprises; and it is possible to foresee the day when commercial success in these operations will depend on the computer system used and how faithfully the computer's instructions are followed.

There is no technical reason to prevent development of similar detailed advisory programs for corn production, irrigation crops, horticultural enterprises, and the like. Decisions on when to spray, when to irrigate, when to harvest, could all profitably be related formally to weather forecasts and probabilities in a way that would preempt the farmer's current decision-making prerogative. Thus the large farmer is potentially

[6] This tendency to obsolescence is widespread. The Canadian Hog Selling Scheme, for instance, uses computers to establish immediate contact between a seller and all potential buyers, thus bypassing the galaxy of intermediary organizations which carry out the same function in the United States. Traditional forms of data collection might be superseded by computer-generated totals produced as a by-product of commercial decisions; futures and stocks could be traded impersonally by computer at a fraction of present costs; and so on.

[7] Corresponding before-tax figures (in the absence of explicit tax-avoidance strategies) were $6 and $16, so that if tax-avoidance strategies were employed their illustration would suggest marked economies beyond the size of current large family farms.

[8] A quite different research/extension pattern would develop from the proposition that "our job is to help *people*."

[9] Or downgrading of middle-management responsibilities, as discussed in the corporate context.

as vulnerable to the downgrading of his lower-level marginal decisions as is his bureaucratic counterpart.

For the smaller operator the increasing economies of size discussed above are disadvantages. Increasingly he will see machinery, credit arrangements, managerial advice, etc. available to larger farmers, but with little or no application to smaller operations. Making his labor more productive on or off the farm is not the focus of any major research or extension effort.[10] He sorely needs the large-scale, coordinated extension program, tailored to his needs, that has been available to expansionist farmers through the Purdue Top Farmer type of program. Research and extension workers would probably find that there was at least as much challenge and need for interdisciplinary cooperation and hurry-up research in the preparation of an extension program for smaller farm operators as there is for the more expansionist type of farmer.

Political Power and the Policy-Maker

The political pressure that agriculture as a whole can exert has declined with the reduced power of the farm bloc. At the same time, however, some individual agricultural interests have taken steps to establish their own lobbies. The dairy cooperatives have been particularly effective in this regard, to the point where they have been able to obtain increased support prices for their products at a time when demand was declining and milk supplies were increasing. In the same way the lime interests have been successful in maintaining the Agricultural Conservation Program despite opposition from the Bureau of the Budget [10].

The increasing importance of large farms in agricultural production raises questions for policy-makers. Arguments for reduced government intervention in agricultural production and marketing can be posed as:

(1) Since farm price support is not an efficient method of raising the incomes of underprivileged rural people and since farm products are an important component of poor people's budgets, can we any longer justify attempts to stabilize farm prices above their long-term equilibrium? What rationale now exists, for instance, for land retirement? Shouldn't lower agricultural prices be *welcomed?*

(2) Given that higher farm prices will benefit principally a relatively small number of large farmers, can our preoccupation with the performance of agricultural marketing firms be justified?[11]

(3) In the absence of government-sponsored production and management research, wouldn't essentially similar services be provided for *large* farmers by the private sector? Does the justification of the experiment stations and extension service, which applied when we had large numbers of relatively small and poor producers, continue to hold when we have a substantially smaller number of large producers? The changing power and profile of our clientele poses the question whether established policies and institutions are not becoming obsolescent.

In contrast to agricultural production, rural *people* are probably in need of more active support from government policies. The fundamental problem is: How to increase the productivity of people displaced from agriculture? This problem has not been entirely ignored, but we need to put still more resources into the study of questions such as:

(1) The potential for recreational enterprises; and the successful management of these enterprises once established.

(2) Industrial operations that can be profitably located in rural communities.

(3) The necessary and sufficient conditions for successful migration from agriculture.

(4) Opportunities for industrial training of rural people.

(5) The sociological structure of hard-core poverty groups.

These are areas where strong cases for federal fundings could be made, even to an urban Congress. The Food Stamp program is an indication of the productivity of American agriculture and a tribute to our desire to relieve the hunger problems of the poorest segment of the community. However, it is a program that treats the symptoms rather than the causes of the problem. We also need programs that will raise the productivity of the poor.

[10] A partial exception to this assertion is provided by the efforts of community development personnel to help rural communities attract apropriate industrial operations. There is, however, an almost total lack of studies oriented to the individual small farmer. What are his needs? His aspirations? His adjustment problems? How can he "withdraw his resources from agriculture?" And would this withdrawal really improve his or the community's welfare?

[11] Why pick on *agricultural* marketing? Shouldn't the nation be as concerned with "efficiency and performance" in our inherently oligopolistic industries?

In contrast to the declining political power of the old farm bloc, the environmental issue has strong (at least strong *verbal*) support in Congress. This is another area where research and new policy proposals are likely to attract support. The environmental lobby is still almost exclusively biological and technical. Even the term environmental economist hardly has meaning at present, let alone being an acknowledged component of the lobby. Much of our trouble with the environment stems from our (meaning basically our profession's) failure to advocate full-cost tax policies. We have all known what was going on, in principle. We cut our professional teeth on the normal inequality of private and social net product in a market economy and on textbook examples of external diseconomies. Yet somehow these fundamental economic concepts have been allowed to remain in a limbo of textbook examples, without any gut-grabbing emotional or intellectual power in the formulation of public policy. In part we have been ignorant of the scope of these diseconomies, but none of us can claim ignorance of the economic principles that lead to the pollution problem. If, for instance, there is concern about thermal pollution as a result of power stations returning cooling water to a body of water above the temperature at which it was taken in, we all know that a necessary condition for rational power station design in a profit-motivated economy is that the marginal cost to the power company of warm water released must be equated to the marginal cost of this warm water to society.

Taxation and regulation are the two major tools open to government in its attempts to control pollution. We need studies of the relative efficiency of regulation versus taxation. We need studies of the economies of scale in pollution control; information systems for the monitoring of pollution; educational programs to extend the economist's idea of the optimum level of pollution rather than the much more expensive technical concept of elimination of all pollution; and studies that would allow us to make some judgment of community preferences with respect to pollution levels.

In addition to these research studies, we need educational programs to counter the "economic ignorance"[12] that characterizes much discussion of the environment. This type of educational program is needed as much by the assailants as by the defenders of the status quo. One of the most important lessons for critics of "the system" to learn is that criticism without constructive proposals for better ways of doing things cannot be expected to lead to change.

The above "digression" into agricultural policy is prompted by the belief that all of our work in the USDA/land-grant college system is powerfully affected by our perception of our area of professional responsibility. If this is too narrowly defined we will ourselves risk obsolescence. This topic was thoroughly explored in Dale Hathaway's Presidential Address [4]. Following is one of his conclusions:

> We also must examine carefully our political support and related financial base, which is increasingly tied to commercial agriculture and, moreover, to a rapidly disappearing segment of that. I am not suggesting that we abandon our service to commercial food and fiber producers, but that we broaden our services and our political and economic support far beyond them.

In summary, so far this paper has emphasized the changing economic and social environment as representing a threat to the managers of agricultural firms. It threatens many middle-managers in corporate firms with downgrading of their managerial responsibilities if they do not graduate to a higher managerial status capable of *designing* computer applications to middle-management problems. The changing economies of size in farming threaten to reduce the returns of farmers unable (or unwilling) to expand to take advantage of these economies. And changing national priorities threaten professional obsolescence to many of us in the USDA/land-grant college system unless we adapt to provide answers to the new questions being asked.

Top corporate management is subject to a rather different impact: Community attitudes are tending to down-grade the *status* of corporate leadership.

Status of Corporate Leadership

A number of considerations have led to a declining public image of large corporations and the free enterprise system. To the extent that the larger agribusiness firms are a significant part of this system, they too share this lower public image.

The very success of the free enterprise system in making (most of) us an affluent society has allowed other objectives than per capita GNP to enter the public preference system. The days of simple faith in high places that "what's good for General Motors is good for the United States" is

[12] I am indebted to Melvin Sims for emphasizing this point.

long past! General concerns focus on the concentration of economic and political power held by large corporations (e.g., an integrator with geographic monopsony, or the milk producers lobby), the apparent inability or unwillingness of our system to solve the poverty problem, the power concentrated in what President Eisenhower identified as the military-industrial complex, and the concern that corporations avoid the full cost of their operations (e.g., the pollution issue). There is widespread skepticism, at least amongst the young, as to whether the corporate-free-enterprise system really is providing the best possible economic and social performance. Associated with this skeptical view of the system is a natural downgrading of its leaders.

To judge by articles in the business press, corporate leadership is sensitive to the impact of this type of criticism and is concerned to rectify any abuses and to avoid government regulation. As mentioned earlier, however, everyone concerned would benefit from educational programs designed to clarify the basic principles of economics as they apply to the quality of the environment.

Lest we think that these criticisms are less applicable to agribusiness than to business generally, we should remember that *Silent Spring* [1] was about the indiscriminate use of the products of agribusiness; and books such as *The Chemical Feast* [9] contain equally alarming statements about food processing and retailing practices.

Status, like beauty, is in the eye of the beholder. One of the impacts of our changing social environment is the reduced faith that simple maximization of private profit will increase general welfare. An increasing number of well-educated affluent young Americans no longer wish to make things or raise the material standard of living; they wish to "relate to people" and improve social justice. They view industry in general as a "public utility," providing the necessary material requirements for society but rather peripheral to the important issues of the relationship of individuals to each other. Business leaders may find themselves likened to the manager of the local waterworks. He produces a product that is essential to urban living, but this does not make him a high-status individual. Thus top management finds it increasingly necessary to justify and defend the operations of the existing system. In the same way, a large producer who used to be held up as a "family farmer" may now find himself characterized as "a serious source of pollution." This is not a pleasant transformation for the ego.

Finally, while on the topic of reputations and social attitudes, the potential conflict-of-interest issue in university consulting should perhaps be mentioned. Very plausible rationalizations are available for the value of consulting in increasing efficiency and hence helping the consumer; in allowing society the benefit of expertise which would otherwise be locked into university departments; and in increasing the relevance and problem perception of the consultants, which benefits improve their research and teaching. But have we given adequate attention to the counter-argument that conflicts of interest cannot be avoided? For instance, the man best able to act as a consultant to provide independent judgment on equitable merger conditions for two firms may also be the person best able to perceive probable antitrust implications of the merger. If he is hired as a consultant, however, he is unlikely to raise the antitrust issue on his return to the university. The possibility certainly exists that the use of public research funds can be motivated more by the likelihood of resulting consulting income than by a simple consideration of the public need. Design of safeguards against such conflict of interest is difficult, and yet the absence of explicit safeguards diminishes the status of both business and university.

Conclusion

This paper has attempted to review the impact of some of the more significant changes in the economic and social environment as they affect middle management in agribusiness, agricultural producers, and professionals in the USDA/land-grant system; and as they affect the status of top management of agribusiness.

In general, it has been argued that this changing environment calls for rather substantial adjustments by managers if they are not to become obsolescent. At the same time our very success in providing for our material wants has resulted in some downgrading of the status of production and marketing as occupations.

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Discussion: WILLARD F. WILLIAMS, Texas Tech University

While retaining high personal and professional regard for Professor Candler, I am compelled by the circumstances, which include my own ideas and biases, to be highly uncomplimentary of his paper. The paper typifies the problem that we as university researchers and specialists have in making any real contribution to management, and this in my view is the relevant topic here today.

After an acceptable introduction Candler successfully evades principal issues and devotes himself to the computer and effects on middle management. In so doing he overstates his case; middle management will adjust as necessary. Candler then turns to the overworked topic of economies of size and the farmer without really dropping his discussion of computers. Much of Candler's discussion of political power and the farmer, if not entirely irrelevant, was misdirected. Implications for management were not clearly drawn. He seems excessively narrow and negative in his concluding section on the status of corporate leadership. The paper is a loose collection of ill-fitting topics largely aside from the mainstream of questions to which we should be addressing ourselves in this seminar.

Among the points that I would like to have time to defend are the following:

1. With the dramatic structural changes that are occurring, the managerial requirements of agriculture and of agricultural business are substantially greater now than earlier and are steadily increasing.

2. There undoubtedly will be fewer farmers and farm managers in the future than in the past, but farm managerial requirements will increase and there will be a greater role for middle management.

3. I tend to agree with Lester Kellogg of Deere and Company who said, "Agriculture in the future will demand and it will have management skills which cannot be provided or assured by inheritance. Agriculture will have management skills equal to those of any industry in the United States" [1, p. 453]. It is because managerial requirements are rising, rather than falling as Candler suggests, that we cannot be sure conventional farmers and ranchers will be able to manage the agriculture and the agricultural businesses of the future. This will depend on farmers themselves and those of us responsible for management training.

4. Social developments, political changes and requirements, the increasing concern of the public about the environment and the changing social status of management all make managerial and entrepreneural functions even more complex.

5. With managerial requirements changing and rising, the type of training needed for agribusiness management should be given careful and continuous study. As A. C. Hoffman has said, ". . . the type of training traditionally offered by colleges of agriculture and by their agricultural economics departments is not, in and of itself, adequate to this purpose [i.e. general business management]" [1, p. 449].

6. Candler's principal point, adopted from Hathaway, seems to be that ". . . it is unlikely that the demand will be sustained for our present services." My reply is that if this is true it is because we are not doing the job to which we have elected ourselves or been assigned.

Candler seems to have adopted a definition of management similar to that provided by Seckler: "The primary function of management in a firm is to organize and direct effort" [4, p. 80]. Managerial capability, it seems to me, is much broader and more complex than this mechanical definition of function implies; it is the ability, according to objectives of the firm, to make effec-

tive and appropriate decisions as needed. Decisions concerning the allocation of all available resources are fundamental, but there are other more subtle requirements, including the capability of simultaneously considering a variety of activities and enterprises, of planning and keeping all activities moving along smoothly and efficiently. An effective and successful manager generally is one with the ability and willingness to recognize conflicting goals and interests, conflicting time schedules, and interlocking constraints. Such a manager also has an ability to establish priorities on both decisions and activities and to compromise effectively. Selzer emphasizes the importance of "flexibility" [5, p. 298]. Hubbard places primary emphasis on "communication" and "human relations" and gives these equal billing with "problem-solving ability" [2, p. 302]. Schrader and French conclude that "in the long run, the ability to manage people and financial management may be the most important areas" [3, p. 306].

The computer unquestionably is a useful tool, but it is only a tool and like all tools is limited in capability. While the tasks of middle management have been made a bit easier, so many more decisions are now required within the context of the word "conduct" that the area of responsibility assigned both to middle management and top management is now much greater. Candler's paper and these comments raise a long list of questions about the type of training needed in agricultural economics for management.

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Discussion: MELVIN E. SIMS, FS Services, Inc.

Perhaps the most pressing change at the moment for managers of farms and agribusiness firms is the increasing pressure from environmentalists, consumer interest groups, and the younger generation with their different attitudes and value systems. The impact of these social changes will, over the short term at least, cause a rearrangement of priorities. Managers will respond to many of these changes by increasing the attention and resources applied to the control of pollution and other items generally associated with an improved social consciousness.

Managers must become involved in this environmentalist crusade so that responsibility, reason, and practicability will be more significant components of major decisions. Effective means must be found to cope with the economic illiteracy that now prevails among many of our social activists. Otherwise they may destroy the very system which sustains their effort.

Candler quite appropriately suggests that the increasing size of organization and the tendency toward larger production units will have a major impact upon managers. These two changes could be consolidated into one and expanded to include the activities involving the coordination of the production, transportation, processing, distribution, and marketing functions into a systems approach for the food and fiber business. If this coordination is achieved by the food marketers or processors integrating backwards to production, farmers would be reduced, as Candler suggests, to little more than laborers. The recent failures of several large corporations attempting to engage in agricultural production indicates that this route has serious implication for the manager.

Farmers, on the other hand, have an opportunity to integrate forward through their own cooperatives, to coordinate the food business into a systems approach, and to preserve many of their decision-making prerogatives. Farmers are becoming more oriented toward general management as the operation continues to grow larger and more complex. I anticipate that many farm-

ers will respond to this change in size and complexity by delegating some of the technical functions, such as marketing and purchasing, to a dependable and trustworthy organization. Farmers will then concentrate primarily on general management and the production function.

Although the computer will have an increasing impact upon managers in the future, I doubt that it should be classified as the major change affecting them. People and financial limitations make the practical application of computer technology far less sweeping than the theoretical possibilities seem to suggest. I agree with Candler that the role of the manager is changed by the computer but do not view the computer as a threat to his prestige or survival. In fact, I welcome use of the computer as an opportunity to think in broader terms and develop a more sophisticated style of management.

The political clout of farmers may diminish as the number of those engaged in farming declines, but this need not be the case. The political strategy must change from that of one depending upon sheer numbers to that of an effective political action group. In fact, present successes seem to indicate some advantage for minority groups.

Management Information Systems

CHAIRMAN: ROBERT F. HUTTON, PENNSYLVANIA STATE UNIVERSITY

Discussion: JAMES T. HALL, Extension Service, USDA

DR. CANDLER in the first few pages of his paper raises the specter of the computer as a threat to middle management. This is particularly acute, he feels, in the area of routine decision-making such as least-cost feed formulation, inventory control, etc.

These are only segments of a true MIS (Management Information System) and do not have as much potential for engendering "technological obsolescence" in middle management as a complete MIS. Such a system would allow top management to obtain, via remote terminals or consoles, the information they now must obtain from a middle-management source. In most areas of agriculture there are no complete MIS's operational at this time.

Top managers in many cases have become disillusioned with MIS's developed to date. They are returning to their original method more convinced then ever that it is still the best technique. If this trend continues, computerized MIS may be more a friend than a foe of middle management.

When designing a computerized MIS, I believe we must:

1. Start with the manager and his problems.
2. Plan with the manager(s) a MIS that he has had a share in developing.
3. Design a sample system.
4. Insist on strict quality control of both input and output.
5. Incorporate appropriate data analysis.
6. Develop clear, concise presentation method.
7. Select an operational system (computer or noncomputer).
8. Test the system.
9. Train input suppliers and output users.
10. Obtain final management approval and initiate the program.

Effects on Firm Managers of Changes in Public Policies and in the Structure, Organization, and Financing of Agriculture

CHAIRMAN: WILLIAM WOOD, JR., UNIVERSITY OF CALIFORNIA, RIVERSIDE

Discussion: VERNER G. HURT, Mississippi State University

THIS discussion is restricted to the impact of changes in market organization and structure upon the managers of firms and the implications for workers in the USDA/land-grant college system. The process of growth and conglomeration and merger has resulted in the loss of some of the prerogatives in decision-making of individual farmers and the owners/managers of the small farms that have merged into the larger organizations (the new middle management). At the same time, the changing organization and structure has increased the responsibilities and problems of the top level decision-makers. In cooperative organizations, in particular, problems associated with membership relations and equitable distribution of gains have been intensified. Just because the merger has resulted in gains to the total organization does not imply that all individual participants in the merger will receive some benfits. In fact, it is highly likely that some of the participants have suffered losses. Top-level management must also recognize and be more sensitive to the changes in economic, political, and social environment created by the merger. The decision-making environment is different because of the changed competitive situation and the importance of public policy and political considerations. Finally, it has been suggested that those of us associated with the USDA/land-grant college system are going to have to develop new strategies and alter our research approaches if we are to effectively serve our agriculture as organized and structured in the future.

Contributed Papers
(Abstracts)

CHAIRMAN: PAUL NELSON, ECONOMIC RESEARCH SERVICE, USDA

Analysis of Purchasing Decision with Multivariate Probit

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DURING the past decade there have been a number of changes in the production and marketing of corn due to the shift from ear corn harvesting to field shelling. Among these changes probably none has had a greater impact than the requirement of artificial drying. Despite the apparent economies of scale that favor drying the grain at the elevator, on-farm drying predominates in much of the corn belt and exhibits a more rapid rate of expansion. This paper reports the results of research undertaken to:

(1) Identify and measure the major economic factors that fostered the recent trend toward on-farm drying.

(2) Estimate the magnitude of the effects of different farm and market characteristics on the probability that a dryer will be purchased.

(3) Discuss the implications of the results for producers and related market sectors.

(4) Describe the appropriate statistical techniques for estimating threshold decision models of durable good purchases.

Multivariate probit analysis was used to estimate the relationship between the decision to purchase a farm dryer and selected farm characteristics. This model was employed rather than the more conventional regression technique for two reasons. First, the decision to purchase a dryer has the characteristics of a threshold model in which changes in the explanatory variables (e.g., farm size) have no observable effect on the decision until the magnitude of change reaches a "breaking point" or threshold. Probit analysis is a statistical technique capable of incorporating the threshold concept.

Second, due to the nature of dichotomous or limited regressand problems, regression was inappropriate for the problem as it was formulated. The ordinary regression approach encounters many methodological and statistical difficulties when applied to threshold decisions.

The results of the multivariate probit analysis indicated that the rapid increase in on-farm drying was a consequence of the increase in field shelling and the continued increase in farm size. Relatively stable variables such as farm type, tenancy, and age of farm operator were also important influences.

The probability of purchasing a farm dryer was found to increase as farm size and percent of corn field shelled increased. The probability decreased as a result of an increase in the percent of corn sold at harvest or the age of the operator. A livestock farm and an owner-operated farm also had a higher probability of purchasing a dryer than a cash grain or tenant-operated farm.

Given a set of values for the explanatory variables, the probability that a particular farmer will purchase a farm grain dryer can be calculated from the estimated parameters. Furthermore, if the mean-values of these explanatory variables for a particular market or region are known, the potential sales of grain dryers in this market can be predicted from these estimated probabilities.

With the addition to a model using "intentions to purchase a dryer within three years" as the dependent variable, it was found that shelled corn storage capacity was not a prerequisite for dryer purchase although the two are often purchased jointly. This implies that drying and storage equipment are complementary products, and sales should be oriented toward a grain-handling system rather than individual components.

Present ownership of a dryer was found to have a significant, positive effect on the intentions to purchase a dryer, suggesting that future sales of farm dryers are most likely to occur as additions to, or replacement for, existing drying systems.

The multivariate probit model employed in this study possesses several significant properties that make it appropriate for a number of research problems: (1) The model incorporates the threshold concept. (2) The model avoids the problem of heteroscedasticity and the difficulty of "$0 > E(Y_i) > 1$" which creates difficulty in the ordinary regression approach. (3) The model provides a sigmoid type of functional relation-

ship between the dependent and explanatory variables which represent the threshold concept. Therefore, in problems where the dependent variable is dichotomous, where a threshold is evident in the decision process, or where a sigmoid type of relationship is assumed, the application of the multivariate probit model is appropriate. Since most economic decisions are dichotomous (or can be formulated as a dichotomous decision problem) and a threshold is commonly observed in most economic behavior and reactions, the model is readily applicable and useful in a broad area of economic research.

Traders' Expectations and Cattle Futures Market Prices

Robert E. Zellner and Charles L. Cramer, University of Missouri

This paper explored the relationship between the expectations of traders of cattle futures contracts, the price of these contracts at their closing dates, and cash prices for cattle. The objective of the analysis was to examine the potential of cattle futures trading as a tool for managing price risk.

Monthly data from August 1965 to April 1971 were used. Since traders' expectations are essentially unobservable, a type of "errors in variables" model involving regressions on unobservable dependent variables was used. Highly correlated lagged endogenous and lagged exogenous variables were specified in the model, so principal components of these variables were used to render them orthogonal. This also reduced the number of parameters to be estimated with limited observations and provided for several lag structures.

Results of the analysis indicated that steer prices lagged one year, and sixteen, twelve, eight, and four weeks before the closing date of a contract significantly affected traders' expectations of a contract's closing price. Traders' expectations of a contract's closing price were negatively affected by steer prices one year and sixteen weeks prior to a contract's close. Their expectations were positively affected by steer prices twelve, eight, and four weeks to a contract's close. In general, contracts at their opening dates have sold for less than ultimate cash prices.

No systematic relationship was demonstrated between the sum of confirmed direct sales of feeder cattle and feeder cattle marketings and traders' expectations of the closing price of a contract. Estimated coefficients for corn prices lagged sixteen, twelve, eight, and four weeks were not statistically significant, but these prices increased the F ratios from regressing contract closing prices and cash prices at closing on lagged corn and steer prices. This was thought to be due to traders' experience in grain trading having peripherally affected their cattle contract trading behavior.

Cattle futures trading would seem to offer potential for managing price risks if the above peculiarities of the market were taken into account. Conventional trading strategies, such as those employed in trading storable commodities, should be modified when live cattle contracts are traded.

Questions Critical to the Successful Financial Management of the Farm Firm—Status of Our Research Answers

VIRDEN L. HARRISON, ECONOMIC RESEARCH SERVICE, USDA

THIS abstract summarizes the findings of a study by USDA that resulted in an annotated bibliography of current and past research in farm financial management in the United States [1]. Some 294 manuscripts and 49 current projects were described in the bibliography.

The following subject areas within farm financial management seem to have been the most popular in recent years: farm corporations, financial strategies, growth of the firm, income tax management, intergeneration transfer and estate planning, investment decisions, and research techniques. Considerable duplication of effort was observed in these and other subject areas.

Emerging and needed areas of research include the following: (1) the study of the financial management practices and decision processes of firms at each stage of their life cycle and the transition between such stages; (2) methods of gradually consuming or disinvesting in an estate over the last 10 to 15 years of expected life of the owner; (3) methods of internalizing and financing costs of production heretofore borne by society, such as environmental pollution; (4) adapting to increased mechanization, doing without chemical pesticides, competing with substitutes for farm products, and adapting to future prices of inputs and products; and (5) the study of lending institutions that provide for a farmer's total loan needs and base his loan on income-earning potential instead of physical collateral.

Let us list six basic questions important in the successful financial management of an individual farm and briefly indicate whether past or current efforts are answering these questions:

(1) What are the immediate and ultimate goals of the farm manager? This is the most important question; if an answer to it is found, answers to the remaining ones are immediately obvious. Yet, of all questions listed, this one is characterized by the least emphasis in terms of effort expended and therefore the least useful information obtained. Economists are not trained to fathom the minds of farmers and require the assistance of anthropologists, sociologists, psychologists, and others in this area.

(2) How shall the farm be financed and operated in each stage of its life cycle—establishment, growth, consolidation, and transfer? Research on this question has taken the form of isolating the stages and studying each; hence growth studies, beginning farming studies, intergeneration transfer studies, etc. Little effort has been expended on studying the transition between stages or the life cycle of firms in its entirety.

(3) What organizational structure is most conducive to accomplishing the goals of the firm? Since researchers have had to guess at the goals of the farm operator, they have approached this question by describing the advantages and disadvantages of each conceivable organizational form. This approach has been effective and the question has been adequately researched, given the level of information on farmers' goals.

(4) What information systems and accounting practices will be required to successfully manage a modern farm? This area has been and continues to be one in which considerable effort is expended. University farm account projects with individual farmers have kept at the forefront in this area.

(5) What criteria should be used in choice among investment alternatives? Again, with farmers' goal structure largely undefined, researchers have had to improvise in this area by assuming the goal of strictly economic profits as the criterion for investment choice. Past and current research, under this assumption, is fairly extensive both within and outside of the agricultural economics profession.

(6) What sources of capital will be useful in accomplishing the goals of the farm organization? Studies of credit institutions and farmers' debt attitudes are numerous. However, each time conditions change (such as institutional innovations and interest rates), the rules of the game change making some of these studies less useful. Research organizations at all levels tend to keep abreast of this issue.

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Equity Analysis and Farm Family Consumption*

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FOR years agricultural economics extension and research personnel have studied farms as if they were debt-free owner-operator production units. In this paper the basic unit is the farm family. The family's present financial position is determined, how it grew to this position, and how it might be expected to grow in the future

Emphasis is placed on the components of the equity section of the balance sheet. A sources-and-uses-of-equity analysis is developed to chart financial growth from the beginning of the business to the present. Four retailed earnings ratios are developed to assist the user in comparing growth on the same farm in different years and on different farms in the same year.

Consumption or "family living expense" is determined as the residual of earnings minus retailed earnings. Information from annual balance sheets and income tax forms is used as the basic data for determining earning and retailed earnings.

It is suggested that the analysis provides a disciplined, consistent system of accounting for the total farm family unit. It can apply to both business and personal interests. The language of the system can help the farmer to better understand his financial growth, and it can improve communications between farmers, their lenders, and their other counselors.

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FORESTRY, PUBLIC PRESSURES, AND ECONOMIC DEVELOPMENT

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Forestry, Public Pressures, and Economic Development

PERRY R. HAGENSTEIN

Now that environmental quality has come to be a major public issue it is somewhat incongruous that a meeting is devoted to the relationship between forestry and economic development. But this is the sort of incongruity that has long been a problem for those who must weigh public pressures as they attempt to define forestry policies. Forestry has always been subject to public pressures and to public intervention, and we have long recognized a conflict with environmental values in the use of forest land to support economic development and economic growth.

Forestry in the United States grew up in a crucible of public pressures, which at one time primarily concerned current and future national economic development. At that time forestry was at the very heart of the conservation movement, which required the mobilization of public pressures to bring about improved practices in the use of natural resources. Today we are in the midst of the second great conservation wave of the century and forestry is again a matter of political concern. Public pressures are forcing changes in what we have only recently come to accept as good forestry practices and in the public policy objectives that have been established for forestry programs.

Perhaps because of their early role in the conservation movement in the United States, foresters were among the first to recognize the conflicts between environmental and economic objectives and to try to resolve them. Nevertheless, public forestry policies and programs were built largely around the objective of economic development, in the sense of contributing to both national and regional economic growth. But for a variety of reasons the formal expressions of public forestry policy, especially those in federal administrative regulations, typically were vague and uncertain as to the relationship between forestry and economic development.

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The lack of clearly defined objectives at one time may not have been critical. Conflicts among possible objectives that could be served by the use of forest lands were not terribly important in many cases. But today, with the growing public pressures for improving the quality of our natural environment, conflicts are often sharp between meeting this objective and meeting other public policy objectives on forest lands. The failure to identify clearly the objectives of forestry policy poses a problem not only for the analyst and the interested citizen but for those who must in the end choose among alternative courses of action.

The early leaders of forestry in the United States were primarily concerned with the use of forest lands to meet industrial and commercial needs and with regional development objectives. In a 1905 letter to the head of Forest Service, who had just been given responsibility for administration of the national forests, the Secretary of Agriculture emphasized that "all the resources of forest reserves are for use . . ." and that "the water, wood, and forage of the reserves [should be] conserved and wisely used for the benefit of the homebuilder first of all." He went on to note that "the continued prosperity of the agricultural, lumbering, mining, and livestock interests is directly dependent upon a permanent and accessible supply of water, wood, and forage, as well as upon the present and future use of these resources under businesslike regulations." And Gifford Pinchot, Chief Forester during this period, often stressed his commitment to the use of the national forests for commercial purposes.

Pinchot's commitment to use of the national forests was partly a matter of political judgment. In reviewing the history of an amendment to an 1897 appropriations act (which became the basic management authority for the national forests) he noted that it included a provision for keeping the national forests open for mining and wrote, "Excellent. What was needed above all things was local approval and support of the Reserves, and use was the key to that" [13, p. 118]. Pin-

chot recognized the importance of public pressures and responded to them, but his beliefs concerning the importance of use of forest land went beyond this. Samuel Hays, in *Conservation and the Gospel of Efficiency* [7], states, "Pinchot's opposition to 'preservationists' and his support of grazing interests did not arise merely from his search for political backing for the transfer [of the national forests from the Department of the Interior to the Department of Agriculture]. These attitudes reflected his basic view that the reserves should be developed for commercial use rather than preserved from it. During the first years of his contact with the forests, in fact, Pinchot felt that his major problem was to restrain the influence of those who wished to leave them in their natural state, untouched by lumberman or stockman. At every opportunity he stressed the utilitarian value of the forests" [7, p. 41]. At another point, Hays says, "The conflict between recreation and commercial use Pinchot found to be extremely hazardous to resolve, but he firmly argued the commercial use of the public lands should precede their use for recreation."

Despite this seeming commitment to commercial use of forest lands to meet requirements for industrial raw materials and to support regional development, foresters have never been very comfortable with economic objectives for forestry programs. Until the post-World War II years, the federal government was the chief employer of foresters and the public lands were not as important as they now are as a source of timber. While the objective of public forestry programs may have been economic development, in fact public foresters were nurtured on a diet of land management that was devoted largely to protection and caretaking rather than use of forest lands to meet various demands. Even on private lands forestry did not come of age as an economic enterprise until the 1950's. In an appraisal of the status of private forestry programs in 1939 Ralph Marquis stated, "The forest industry at the present time is undergoing a great change. . . . It is not until the virgin stands of timber face exhaustion, not until the remaining stands are absorbed in private ownership or government reserves, not until the remaining forests are far removed from consuming centers that economic forces permit the practice of forestry on a profitable basis" [11, p. 166]. He was right, and it was these conditions in the 1950's that brought private industrial forestry to the point where investments in forest management were being made on the basis of economic judgments rather than on the basis of biological mysticism.

Although industrial owners who must have raw materials if their business is to continue became interested in forestry, trees still grow slowly—so slowly, in fact, that the rate of tree growth over a long period of time seldom exceeds the level of interest rates obtainable on other types of investments. Prior to the 1950's foresters had made attempts to remove certain economic impediments to the practice of forestry. One of these was property taxes, which were seen as encouraging the depletion of timber resources [4]. As a result of the studies that were made a number of states provided special methods of taxing forest lands. Another approach was governmental assistance to forest landowners in the form of technical advice and management or in the form of subsidies for certain forestry practices. This was in addition to federal support to the states for forest fire, insect, and disease protection programs, which lowered the risk to the landowner of making investments on his land. But neither the modifications of property taxation nor the various forestry incentive programs were wholly successful in overcoming economic barriers to forestry practices on nonindustrial private lands. Foresters tended to regard the objective of economic development and the process of economic analysis with skepticism.

On public forest lands there was also resistance to economic development as a clearly defined policy objective even after the economic rationale had been accepted on private industrial forest lands in the 1950's, despite the strong timber production rationale in statutes providing for the acquisition and management of federal forest lands. The failure of economics to gain a strong foothold in forestry decisions on public lands in the 1950's must be laid in part to rapid increases in the use of forest lands for outdoor recreation, for which a traditional market system did not exist. Public pressures built up rapidly for using public lands to supply outdoor recreation opportunities, although the chief statutory objective for these lands was timber production. In response to the need to recognize outdoor recreation as an appropriate use of public forest lands Congress passed the Multiple Use and Sustained Yield Act of 1960 [15]. But in so doing it denied economic development as an overriding policy objective and failed to provide a substitute. The 1960 Act states that "consideration be given to the relative values of the various resources, and not necessarily to the combination of uses that will give the greatest dollar return or the greatest unit output." In defining sustained yield as "the achievement and maintenance in perpetu-

ity of a high level annual or regular periodic output," the Act defines one objective for the management of national forest lands, but other objectives that might help in choosing among possible combinations of outputs are left to the imagination of the program administrator and the analyst.

When we look elsewhere for guidance as to what constitutes the objectives of public forestry policy, we find that present overall levels of financing on the national forests suggest that the appropriations process, at least, gives greater consideration to those activities that produce a commodity that is valued in the market place than to other possible uses of the national forests. On the other hand, the allocation of appropriations among various investment opportunities provides some evidence that in fact economic criteria may not be the major guidelines followed by the Forest Service for forestry investments. The Public Land Law Review Commission obtained estimates of expenditures on timber management activities of the Forest Service by major regions of the country. For 1967 estimated timber management expenditures were allocated to the major Forest Service regions as follows [21]: North 10.4 percent; South 16.4 percent; Mountain 30.3 percent; Pacific 42.9 percent. In 1968 a special study prepared by the Forest Service as part of its Planning-Programming-Budgeting System classified investment opportunities for timber management intensification on the national forests according to the potential yield in terms of interest rates. This study indicated that $210 million could be invested in timber management on the national forests and earn a return of at least 7 percent and that $339 million could be invested and return at least 5 percent on the investment. The regional distribution of these investments would be as follows [12]:

	Return of at least 7 percent	Return of at least 5 percent
	percent	
North	12.9	12.4
South	41.4	27.1
Mountain	14.8	23.9
Pacific	30.9	36.6
	100.0	100.0

Estimates of the actual timber management expenditures show that 73.2 percent of the appropriations were allocated to the Mountain and Pacific regions together, although the estimate of the allocation that would be made if it was required that 7 percent be earned on timber management expenditures was 45.7 percent. If 5 percent were the guiding rate, 60.5 percent would be allocated to these regions. Although it seems clear that the allocation of timber management funds among regions is not based only on economic criteria, the actual basis on which the allocations are made is unclear. While the 26.8 percent of the funds allocated to the North and South regions is reasonably close to the proportion of commercial forest lands on national forests in these regions (22.4 percent), the proportion of funds allocated to the two western regions is not clearly related to the area of commercial forest lands. Nor do the proportions of timber sold or total area of national forests shed much light on these allocations, as shown in the data below for the national forests:

Region	Total area	Area of commercial forest land	Timber sold, 1967
		percent	
North	5.9	10.2	6.1
South	6.5	12.2	8.5
Mountain	53.3	43.8	23.4
Pacific	34.3	33.8	62.1
	100.0	100.0	100.0

Timber management expenditures undoubtedly have effects on resources or uses of forest lands other than timber, and the allocation of funds among regions perhaps reflects these effects too. But one must at least suspect that there is an unwillingness on the part of those who make public forestry decisions to use economic criteria even where the particular output of forest lands is one that enters into commercial channels. The Public Land Law Review Commission asked its advisory groups to respond to the question: "To what extent should timber management, timber disposal, and investment in timber production on the public lands be guided wholly or largely by economic considerations?" It was understood that this question concerned timber as a separable, and commercial, product of the forest. The Department of Agriculture replied that ". . . we do not believe that maximization of returns on investment in timber is wholly compatible with the purposes for which the National Forests were created. In this sense, economic considerations may encounter an immediate and basic conflict

with longstanding conservation principles of multiple use and sustained yield. We feel that the public interest is best served by attempting to optimize the combination of all benefits under the multiple use concept, even though it is difficult to quantify the intangible values which should weigh heavily in resource decisions on public lands."

The question to which the Department of Agriculture was responding may well have been based on a misguided notion that the objectives of forestry programs on public lands can be compartmentalized and treated individually as though they bear no relationship to other objectives. In fact, timber management and disposal programs have an effect on other outputs of public forest lands. On the other hand, public funds are invested in specific programs designed to improve the quality, quantity, and timing of timber production from public lands for commercial purposes. A more responsive answer to the question might have discussed how economic considerations conflict with the "conservation principles of multiple use and sustained yield." Or it might have discussed the basis on which "intangible values" would be weighed along with economic values. The lack of such responses can almost surely be laid to the Department's discomfort with economic development as an objective of forestry policies in the face of public pressures related to environmental values.

Contribution to regional income generally has fared no better than contribution to national income as a specified objective of public forest land management. While "community stability" has been recognized explicitly in federal law as an objective to be served by some public forest lands [16], it has not been the basis for a recognizable policy of regional economic development. At least in part this can be attributed to the difficulties of identifying and measuring regional economic impacts [19]. Although regional economic impacts have been at issue in forestry decisions for years, the development of useful and practical decision models and information has not really progressed far enough to give those who make public policy and program decisions the opportunity to accept or reject expected impacts on regional income as a guide to their decisions. Necessarily, much of the research that has been done has been descriptive [3, 14]. The use of regional input-output analysis in forestry decisions is promising, but data collection is often expensive and the usefulness of the data limited to a specific decision or two [6].

To sum up to this point, although the production of timber, a marketable commodity, was long identified as the major objective of forestry programs on federal lands, the economic rationale for management decisions was never developed very explicitly. In view of mounting public pressures for an improved environment, the lack of an explicitly developed economic rationale for some past decisions on federal lands is now proving to be a troublesome problem. One example involves clearcutting, a timber management practice that is now a focal point for the expression of public pressures on public forestry policy.

Clearcutting, one means of harvesting timber to assure regeneration of desirable tree species, has come into disrepute among environmentalists. It was the subject of hearings by a subcommittee of the Senate Interior and Insular Affairs Committee in April and May 1971. The hearings focused in part on a report, prepared by a select committee made up of University of Montana faculty members, evaluating timber management practices on the Bitterroot National Forest. This committee was critical of the practice of clearcutting because of its severe environmental impacts, but it notes that "very little has been said about the economic aspect of the practice [of clearcutting]" in a Forest Service review of management practices on the Bitterroot. The committee concludes that "the only way to justify the practice is to *ignore* economic analysis as a tool of decision-making" [2].

However, when viewed in terms of the existing Forest Service statement of objectives, one can readily see how economic analysis might be ignored even with respect to investments in timber production and such practices as clearcutting. The following objectives, taken from the Forest Service Manual, are the set of policy objectives that provide the umbrella for specific programs [18]:

1. Promote and achieve a pattern of natural resource uses that will best meet the needs of people now and in the future.

2. Protect and improve the quality of air, water, soil, and natural beauty.

3. Help protect and improve the quality of the open space environment in urban and community areas.

4. Generate forestry opportunities to accelerate rural community growth.

5. Encourage the growth and development of forestry-based enterprises that readily respond to consumers' changing needs.

6. Seek optimum forest landownership patterns.

7. Improve the welfare of underprivileged members of society.

8. Involve the public in forestry policy and program formulation.

9. Encourage the development of forestry throughout the world.

10. Expand public understanding of environmental conservation.

11. Develop and make available a firm scientific base for the advancement of forestry.

Of the 11 stated objectives, 7 are actually statements of program scope (e.g., "develop and make available a firm scientific base for the advancement of forestry") or means of accomplishing objectives (e.g., "seek optimum forest landownership patterns"). While at some point it is important to identify the scope of an agency's programs and the means it will use in pursuing its objectives, it is disquieting to find that program scope is confused with objectives. Two of the remaining objectives involve equity considerations ("generate forestry opportunities to accelerate rural community growth" and "improve the welfare of underprivileged members of society"). While one might argue that these objectives imply a relatively limited view of public policy on equity matters, both are within the scope of Department of Agriculture policy and reflect recent policy directions.

Of the remaining objectives, one ("protect and improve the quality of air, water, soil, and natural beauty") might well be viewed as a subset of the other ("promote and achieve a pattern of natural resource uses that will best meet the needs of people now and in the future"). The latter is so general that one must look further to determine whether it has any meaning.

A list of 12 subobjectives in the Forest Service Manual provides some help. First it provides a list of the kind of physical outputs or uses that can be expected on forest lands, ranging from timber and minerals to recreation and wilderness. Beyond this, however, we find the same kind of perplexing objectives as in the major list. Again, there are statements of program scope (promote high quality multiple use "on other ownerships") and activities ("share expertise" and "cooperate with others"). With respect to specific commodities, the objectives are to "develop and promote national programs that meet the nation's need for timber" or to "help insure water yields of the quality and quantity needed." Again the objectives are general and fail to specify a context in which "needs" can be considered. Are needs to be considered within the context of a market economy? Are needs for timber and water to be weighed in the same manner? And what weight should be given to long-run needs as contrasted with short-run needs?

Whatever the present rationale for federal forestry policy, neither economic development nor economic growth is mentioned as an objective in the policy directives of the major forestry agency in the country. Perhaps this is not so surprising if one considers the kind of public pressures on government agencies as a result of public concern with environmental quality. As the president of the Sierra Club stated with respect to the recent report of the Public Land Law Review Commission: "The basic premises and assumptions of the Report are wrong. The Report assumes that the twin evils of (1) population growth and (2) the notion of a limitless, ever-expanding economy are here to stay. . . . The basic conclusion of the Report is that the one-third of the nation's land belonging to the Federal government must be utilized to the full for production of commodities, and if necessary sacrificed, to satisfy the fires that glow in memory of the archaic Chamber of Commerce cliche that economic growth is necessarily always progress, necessarily always good and necessarily always desirable" [1].

In view of this kind of concern with economic growth as an objective of forestry policy, which has always been sensitive to public pressures from conservationists, one can understand why policy statements might well be couched in terms that hide economic development as a policy objective. On the other hand, economic development is a general federal policy objective that has been given statutory recognition. It is clearly an objective for which public pressures exist just as they do for environmental objectives, although public interest in environmental objectives overshadows that for economic development today. Public forestry policy should reflect both economic and environmental objectives.

If we decide that economic growth is still one valid public forestry objective along with others, and clearly identify it as such, we are still faced with the problem of comparing it with other valid objectives. Do economic models provide the best starting point for an analysis of public policy issues that involve economic and other objectives, especially those related to environmental quality?

K. William Kapp [9] argues that economic theory still is inadequate for dealing with envi-

ronmental and social costs of public policy. He writes, "Both micro- and macro-economics fall back upon the formal concepts of 'externalities' and of cost benefit analysis, but the fact of the matter is that the theoretical presuppositions and logical framework of pure economics from which these concepts are derived are too narrow and too static to be useful for the study and interpretation of the processes that give rise to environmental disruption and social costs." Having disposed of economics as a basis for establishing public policy objectives and for the analysis of policy issues, Kapp turns hopefully to an analysis of government itself to provide some clue as to a theory of social choice. He writes: ". . . the fields of public administration and administrative behavior in general provide the empirical material in the light of which it may be possible to erect a general theory of social value" [9]. Even if the circularity of this notion (look at government program objectives to find out what the objectives should be) could be overlooked, current federal forestry policy does not suggest that this provides a good starting place. The translation of public pressures into identifiable objectives of public forestry policy has not been accomplished. As the uses of forest lands have become diverse and the level of use has increased since the early part of the century, the objectives of public forestry policy have necessarily grown more complex. But as these objectives have developed beyond the original one of assuring that timber would be available to meet the objective of national economic development, the expression of policy, both in statutes and in administrative directives, has become increasingly vague.

In at least one other area of federal responsibility for natural resources this has not occurred to the same extent. For federal water resources projects the basic criterion is that "the benefits to whomsoever they accrue shall exceed the costs" [5], but this criterion and procedures for analyzing projects have been progressively improved over the years in the "Green Book," Senate Document 97 [17], and more recently in a statement of procedures being developed by the Water Resources Council [22]. The development of these procedures and the definition of criteria for evaluating projects has been the subject of open debate and discussion [8, 10]. Both procedures and criteria have been changed and improved as public policies have changed in response to public pressures. The fact that development of the framework started from an economic analysis base has not precluded building in environmental considerations as public pressures have shifted. If anything, the preparation of environmental statements to meet the requirements of the National Environmental Policy Act has shown the utility of having a defined analytical framework already available.

Finally, some consideration should be given to the institutions created to serve the forestry policy objectives of the federal government. The two chief institutions are public ownership of a large area of forest lands and cooperative programs for federal sharing with the states of the cost of forest protection and rehabilitation. Of these, land ownership is most significant because it is largest, and it is here that public pressures are greatest. Federal ownership of forest lands and timber resources now includes some 20 percent of all forest lands in the United States suitable for the production of timber products, some 40 percent of the total volume of wood fiber in standing trees, and some 60 percent of the total volume of softwood saw timber, an important input to the construction industry and the mainstay of the lumber and plywood industries. Federal ownership of forest lands came about as a result of the concern at the turn of the century with timber production and a belief that the nation could run out of timber. Just as forest land can be used in many ways to meet a variety of objectives, however, the institution of forest land ownership has proven that it too can be used in various ways. As leisure time and personal income have increased, the public demand for outdoor recreation has increased. Lands that were placed or retained in federal ownership for quite different purposes have been valuable in meeting recreation demands.

The pattern of federal land ownership, however, has been relatively inflexible. While uses on a tract of federal forest land can be readily changed, the pattern of ownership itself is not readily changed. This is evident in the work and recommendations of the Public Land Law Review Commission, which was charged with recommending needed changes in federal laws and policies with respect to the retention or disposition of federal public lands. Long before the Commission published its report [20] and indeed well before the Commission had reached even tentative conclusions, the chairman of the Commission made public statements that the Commission was not going to recommend disposition of the national forests. Despite the fact that

some 85 percent of the national forest lands and some 95 percent of all federal lands are located in the western one-third of the country, serious consideration was never given by this Commission to the possibility of trading some of these lands for lands in the eastern part of the country where public pressures for outdoor recreation are greatest. The chairman and other commissioners, and even most of those in its advisory group who favored substantial disposition of the remaining unreserved public domain lands, tacitly recognized that major shifts in the ownership pattern of the national forests are politically untenable.

The inability to change significantly the ownership pattern of public lands has considerable significance for the identification of public forestry policy objectives. The fact that public forest lands are not evenly distributed throughout the country determines in part the objectives that can be met by these lands. In particular, this means that regional economic development will necessarily be an important objective of forestry policy because public forest lands are concentrated in underdeveloped regions of the country. Further, the existence of direct control over significant forest land areas is likely to lead to emphasizing some public objectives rather than others. The large federal role in supplying outdoor recreation opportunities, for example, is directly related to the fact that there was suitable land in federal ownership at the time public demand for outdoor recreation was increasing rapidly. Control in the hands of vigorous federal agency leadership looking to an expansion in its responsibilities assured that the federal government would play a large role in supplying outdoor recreation opportunities. That the Public Land Law Review Commission found that public sentiment apparently strongly favors continued federal ownership of forest lands—so strongly that the Commission believed recommendations to dispose of a significant part of it would be futile—suggests that existing ownership patterns can be accepted as public forestry policy is modified to meet changing needs.

The level and variety of uses of forest lands will surely continue to increase in the future. And there will be a continuing need for a public forestry policy that is responsive to public pressures. But until we have a new system of social accounting that will broaden our concepts of economic development so as to include other environmental and social values now outside of our concept of economics, the validity and usefulness of economic development in terms of both national and regional economic growth should be recognized. Without a clear commitment to economic development as one of the objectives of public forestry policy, we have no clear policy at all. Each additional response reflecting public pressures will add to our confusion as to the content of public forestry policy. And like Buridan's ass, who could not choose between two equidistant bales of hay, forestry as a useful practice will wither away for the inability to choose among possible courses of action.

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Discussion: RALEIGH BARLOWE, Michigan State University

Hagenstein has emphasized a dilemma in present public forest policy—the problem of giving direction to public forestry programs in the absence of clear-cut objectives. In facing up to the questions he has raised, consideration should be given to two basic issues: (1) reselling the nation on the economic worth of forests, and (2) reappraisal of the multiple use concept.

The reselling program must start with the forest decision-makers. As Hagenstein has observed, many policy decisions have been motivated more by "biological mysticism" than by convictions concerning the economic worth of forest products. A reselling job also must be directed at the public to undo the misconceptions generated by those misguided prophets who have proclaimed that we can prosper as a people without further economic development.

Those who argue that economic growth is undesirable have simply failed to think through the consequences of their arguments. Zero population growth cannot be achieved overnight. If we could reduce our rate of population growth to a bare replacement level now, we would still have to wait until 2039 for a stabilized population with relatively even numbers of people in the pre-60 age brackets. Meanwhile, barring unforseen catastrophes, total population would increase approximately 35 percent. We would have 50 percent more people in the 20 to 65 age brackets and would need 40 to 45 million additional jobs. This calls for considerable continued economic growth unless we plan to divide our present work load among the larger working force. Without additional economic growth we must also be willing to trade our present affluence and our dreams of even higher levels of living for universal poverty.

We need policies that will promote economic growth and at the same time enhance the environmental values associated with forests. To attain this end we must reappraise the concept of multiple use. Many desirable practices have been justified in the name of multiple use, and this concept most certainly should be considered in devising future policies. At the same time, however, we must recognize that multiple use has become a trap for policy. Once the door was opened, every conceivable user of the public lands has been able to argue that his use is as important as the production of products of economic value.

With multiple use as the guideline, our forests have become all things for all people. This is an untenable situation. The objective of forest management should be that of optimizing economic and social returns over time. To attain this end priorities must be expressed between objectives. Most objectives can be pushed, but not all at the same locations. Areas should be classified and utilized according to the dominant uses or combinations of uses for which they are best suited and most needed. Programs of this order are necessary if we are to avoid a complete impasse in forest policy.

Discussion: HENRY J. VAUX, University of California, Berkeley

Dr. Hagenstein concludes that policy governing the national forests lacks a sufficient foundation of clearly defined objectives. The Multiple Use-Sustained Yield Act specifically delegates to the administrative branch the responsibility for determining what measures and what trade-off ratios should be used to make land-use decisions, in the light of the multiple criteria specified by the law. When one examines the actions taken by the Forest Service, it is clear that explicit priorities and trade-offs have been used to implement the Multiple Use Act. In the case of the Juneau Unit Timber Sale on the Tongass National Forest, economic development of Alaska has been clearly established as the overriding policy goal. In numerous multiple-use planning guides published by the Forest Service, specific hierarchies among timber production, watershed protection, recreation, and other sorts of forest values have been established and have been used as the basis for multiple-use management plans for specific areas.

Thus the problem arising out of conflict between the goal of economic development and goals underlying various public pressures is not one of failure to identify goals and trade-offs. Instead, the difficulties arise because the Forest Service's determinations regarding value trade-offs have not received the general concurrence of either pressure groups or the Congress. The present spate of lawsuits over Forest Service land-use decisions suggests the extent of the disagreement from pressure groups. The budgetary history of the Development Program for the National Forests evidences Congressional disagreement by disclosing that, over the first six years of the Program, 94 percent of the timber management target was financed in contrast to only 47 percent of the recreation-public use target. The problem thus appears to be primarily how to validate in the eyes of pressure groups and the Congress whatever value trade-offs are to be used and only secondarily how to define the values themselves.

Hagenstein criticizes the long-term forest investment program on the national forests because decision-makers do not appear to be sufficiently sensitive to economic efficiency criteria. Examination of the Marty-Newman study of the comparative efficiency of timber-growing investment on the national forests shows that the results are (1) highly sensitive to differences in the interest rate which is employed; (2) dependent on arbitrary allocation of certain costs to nontimber objectives, with consequent possibilities for bias; and (3) quantifiable only on the basis of assumptions about future prices to which great uncertainty is inevitably attached. In the face of these considerations, perhaps we forest economists should be asking ourselves how to take better account of the real world in which our problems are imbedded rather than asking administrators to take more seriously our existing market-constrained, computer-bound, uncertainty-ignoring models. W. A. Duerr has discussed the problem and seems inclined to say that we can make progress only through faith. Perhaps so. But closer study of flexibility rather than efficiency as a criterion of economy might be as fruitful.

Changing Pressures on Forest Land Resources: Recreation, Water, and Other Nontimber Values

CHAIRMAN: JAY M. HUGHES, COOPERATIVE STATE RESEARCH SERVICE, USDA

Discussion: RICHARD L. BURY, Texas A&M University

As Dr. Hagenstein mentioned, outdoor recreation has impinged considerably on forest management policy, especially in the U.S. Forest Service which now receives more recreational use than any other federal agency. Impingement has occurred through the operation of such forces as (1) level of living and stage of national and regional economic development; (2) national life styles and standards of living; (3) relative strengths of preservation groups and utilization groups; (4) attitudes toward forest resource management held by politicians, legislators, and the general public; (5) the impact of opinion-makers and style-setters such as President Kennedy; and (6) the relative demands for wood products and for outdoor recreation.

Pressures for recreational uses of forest environments have shifted about 3 percent (16.2 million acres) of the nation's productive timberland from harvestable to nonharvestable status. Current projections for 1960–2000 call for a triplin of timber demand and a fourfold increase in out door recreation demand. Total withdrawals ar likely to reflect the relative strengths in deman for timber products and forest recreation, thei prices relative to substitutes, and the sociolog cal-political forces discussed above.

In response to aesthetic impacts, recreatio also affects timberlands left in harvestable statu through conservative revision of timber growt practices in roadside and water influence zone and in major vista areas.

Optimum allocation of forest resources, as Ha genstein suggests, must rest on a new system c social accounting if economics is to provide framework for rational decision-making. Such system of social accounting would require norma tive evaluation of the relative worth of the sev eral forest products, which may be very difficul or impossible through current economic theories

Discussion: DANIEL E. CHAPPELLE, Michigan State University

What is the role of models in the analysis of public policy issues that involve diverse objectives, including many related to environmental quality? If "requirements" must be met, an adequate level of social welfare maintained, and deleterious impacts on the environment minimized, then more comprehensive and highly coordinated planning must be implemented. Planning of this type requires a foundation of highly sophisticated models to simulate the complex linkages and interactions between the various biological, physical, and behavioral subsystems of the forestry system.

It is argued that the forestry economy is largely a planned economy, albeit poorly planned, characterized by administered prices and important environmental impacts, and populated by spatial monopolists and oligopolists on both buying and selling sides, depending upon whic good or service is being referenced.

Policy analysis models must be comprehensiv have a multidisciplinary orientation, and be bot temporally and spatially dynamic. It appear that large-scale gaming-simulation models ar more likely to be operationally significant in nat ural resource policy analysis than other ap proaches. Such models would consist of a multi tude of modular submodels, each designed t mimic a real-world subsystem of the forestry sys tem. They must include consideration of a goods and services of the forest, priced and non priced. Since decision-makers are concerned wit both programmed and nonprogrammed decisions and decision processes in many cases defy model ing, it is necessary that decision-makers assum roles in these models.

Discussion: R. BURNELL HELD, Colorado State University

Abundant evidence points to a changing power situation relative to the types and kinds of uses made of forest land and water resources. A court injunction has been used to halt a timber sale. Legislation directing an accelerated timber har vest was defeated in Congress. A Public Lan Law Review Commission recommendation of "dominant-use" philosophy designed to favc

timber production was quick to draw criticism. Forest Service clearcuttings in West Virginia, Montana, and Wyoming have received sharp criticism and inspired Senate hearings and a proposed two-year moratorium on all clearcutting. Forest Service study teams have also found fault with the application of clearcutting.

Institutional biases, lagging response to public desires, inadequate information on the production possibilities of a given set of resources, and federal funding procedures tend to favor resource uses that generate money income. Although nonmarket values are recognized it is doubtful that they receive priority attention as much as they deserve. Means must be found to recognize and reflect credit to the managing agencies for those efforts that create significant on-site and off-site values. If it is impossible to internalize the presently external costs and benefits related to the use of natural resources on federal lands, what hope is there that similar problems can be solved in the private sector?

Influence of the Public Sector: Resource Ownership, Regulation, and Incentives

CHAIRMAN: TOM HAMILTON, FOREST SERVICE, USDA

Discussion: RONALD BEAZLEY, Southern Illinois University

IF, as I shall attempt to demonstrate in the next few paragraphs, the polar public and private views of forestry are rationally impossible, and thus not practically useful, what view is desirable?

Forestry is centrally concerned physically with *interdependencies* of ecology and silviculture. Consequently its economies of production of multiple goods and services is dominated by jointness. The same is true, analogously, in consumption. Economically and socially forestry is centrally concerned with *investment*, characterized by spatial fixety, great temporal longevity, many externalities, and in some instances uniqueness.

Given these characteristics this resource cannot be expected to meet the goals of society under private profit motive enterprise, even assuming perfect markets; nor, given the democratic culture of the United States and its structure, can optimal goals be met within a purely public, nonprofit, centrally directed enterprise.

The consequence must be a forestry that is quasi-public and private in order to attain the general social goals of society: efficiency in allocation, equity in distribution, increased economic growth and consumption, stability and security in the economy, some contribution to national self-sufficiency, and regional optimality in all these respects.

The conclusions are (1) that these social goals and criteria must be taken into consideration in private profit-making enterprises where "economic" or market efficiency is very important and (2) that these same social goals must also account for private-sector opportunity costs in the case of nonprofit social enterprise. Of course social decision-makers must not behave "as if" the decisions were being made in a profit-making context. Given this view it is much more likely that we shall achieve the socioeconomic optima of multiple objectives that actually confront us, recognizing the political and cultural constraints which themselves make the optima possible.

Discussion: DANIEL W. BROMLEY, University of Wisconsin

In analyzing the role of the public sector as it influences natural resource use and development it is necessary to recognize at least three levels in the transmission of policy guidelines to operational activity [3]. Following Wantrup, the lowest level is the operating level where the day-to-day management decisions are made within the broad guidelines provided by the second level. The second level is the institutional one, and here the very broad social goals of the specific institution are translated into agency manuals and official agency posture on the issues of relevance. The term "policy" is reserved for the third level and it is here that the political process articulates the nature of the institutional constraints of the second level. Each level is directed by the level above it.

Hagenstein argues that whereas economic development once provided clear direction for the management of public forest lands, competing demands now render management decisions in response to rational sanctions nearly impossible; there is said to be no policy at all. Yet it seems that economic development was never that clear a policy guideline and in fact was a mere legitimization for foresters to do those things for which they were best equipped—produce trees. The "slippage" between the policy level and the operational level provided ample opportunity for the latter to operate uninhibited by policy guidelines.

Economists, accustomed to constructing scientific fictions for the maximization or minimization of some objective function by a single decision unit, are experiencing considerable professional insecurity when it comes to the issue of policy in the public sector. The major barrier is that instead of the reliance upon relative prices to determine choice it is now necessary to recognize that often (political) choice will determine

relative prices. Rather than diminishing the role of the economist in policy, however, that role now takes on a new dimension.

Specifically, it would seem that the nature of community preference functions for natural resource use and development might be inferred if sufficient care is taken in informing the "consumer" of the specific attributes of the "commodity" and its "price" relative to other goods and services. Work currently under way at the University of Wisconsin is directed towards the full specification of the "social production function" of water resource projects such that the full array of monetary and nonmonetary impacts are identified by location and by the group of individuals affected [1, 2]. Then when decisions about water resource projects are made, with the bulk of those significantly affected being party to those decisions, it would seem that much could be learned about the nature of the community's preferences. With this, one has information feedback not only for articulating policy (the top level) and for helping to design institutions (second level) to insure the achievement of that policy, but for the very crucial task of specifying operating procedures of the appropriate agencies (the first level) that are fully consistent with the policy pronouncements.

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Discussion: JOHN MUENCH, JR., National Forests Products Association

Once the public understands the role of renewable forest resources in replacing depletable and pollution-inviting mineral resources, the forester's dilemma will be eased and increased timber production through more intensive management will be demanded. Public regulation of private forest practices has been used in some states to obtain conservative cutting practices and adequate regeneration on private lands. But regulation will be inappropriate to the investments needed for intensive forest management. Removal of economic impediments and the promotion of incentives for private landowners will be necessary. The fact that more affluent forest landowners and owners of larger properties are the ones most inclined to practice high level forest management suggests that impediments are still too great and incentives, including public subsidies, are inadequate for most small forest owners.

The general classes of impediments to improved forest management on private lands are:

1. Lack of technical knowledge.
2. Risk from fires, storms, and other damage.
3. Diseconomies of small scale.
4. Lack of equipment and manpower.
5. Poor availability of investment capital.
6. Excessive taxes.
7. Attitude of owners and public against timber growing and harvesting.

Additional impediments are the shortness of an owner's tenure, rural poverty, and instability of markets resulting from national economic cycles. But these are beyond the scope of public forest policy. Other "problems" sometimes mentioned, lack of markets and uses for low quality timber, beg the question of why increased timber production is desired in the first place.

Contributed Papers
(Abstracts)

CHAIRMAN: I. I. HOLLAND, UNIVERSITY OF ILLINOIS

The Forest Investment Decision in a Time of Change

WALTER C. ANDERSON, FOREST SERVICE, USDA

INCREASED capital expenditure by investors to intensify forest management is abetted by advances in harvesting techniques and utilization technology, but threatened by a growing concern for the natural environment.

The take-off stage for forest investments is near. Domestically, industrial wood consumption appears to be on the verge of a sharp increase. The United States may soon become a net exporter of wood products. Concurrently the forest land base for timber production is shrinking. Increased investment is also favored by reductions in the risk of loss and greater accuracy in predicting the outcome of investments.

Because of the extensive area of below par stands, investments will be common in timber stand improvement and type conversion. Timber stand improvement is attractive to investors because the cash outlay is minimal, the payoff period is short, and the rate of return is high. Type conversion, by contrast, requires a high cash outlay and has a long waiting period. Because of the high cost, high degree of technical sophistication, or both, these practices are sensitive to changing external factors.

Some changes make investments more attractive. The advent of tree-length logging and large-scale substitution of capital for labor in harvesting increase the unit value of stumpage and give managed stands a marketing advantage. Product value was increased by the breakthroughs in peeling southern pine for plywood and in pulping sawdust. Also, the adoption of high-speed, in-line sawing systems enhance labor productivity. Furthermore, the product possibilities of small logs has been expanded by the development of end and edge gluing for fabricating boards and overlays to upgrade them.

Environmental concerns, on the contrary, could make forest practices more costly and difficult to execute and less effective. Prohibitions against chemical methods of cull tree and brush control could force the use of less efficient mechanical means. Loss of growing space by retaining trees beneficial to wildlife could reduce revenue from timber. Restrictions on the size of areas clearcut or planted could negate economies of scale in type conversion. Forestry will be challenged to enhance the attractiveness of investments in the presence of constraints on practices.

Influence of Public Policies on the Development of the Forestry Sector in British Columbia

DAVID HALEY, UNIVERSITY OF BRITISH COLUMBIA

IN British Columbia about 95 percent of the Province's 137 million acres of forest land is publicly owned, and the forest administration is firmly committed to almost total economic involvement in the forestry sector. Through a complex system of land tenures and timber cutting rights, influence is brought to bear on resource pricing, forest industry structure, industrial investment policies, regional economic development, and product mix. In the pursuit of economic stability for the communities dependent on the forest-based industries and the full utilization of the timber resource, competition for public timber has been eliminated and vertical integration within the forest industrial sector has been encouraged. The development of forest policy in British columbia has been pragmatic and planning on the whole intuitive, involving a minimum of formal analysis. Both the objectives and execution of forest policy can be severely criticized on many grounds; nevertheless, in many respects it has been successful in achieving the goals of the administration.

Forest Range Environmental Study (FRES)

John W. Putman, H. Fred Kaiser, and David P. Worley, Economic Research Service, USDA

The Forest Service of the U. S. Department of Agriculture, is taking a fresh look at the range resources of the United States in order to develop a new program for range management and research. The study objective is to suggest a more efficient combination of land management strategies to be used in attaining the Forest Service's goals for the resource range. Overall the study has covered 1.2 billion acres of native and natural grasslands, permanent pastures, and commercial and noncommercial forests.

To give a baseline from which to start, the lands were first inventoried. Land units called resource classes were established, each classified as part of 1 of 34 ecosystems, 4 productivity classes, 3 condition classes, and 3 ownerships. Each resource class was examined under 6 different simulated levels or intensities of management. Forest Service experts estimated practices required to achieve the goals of each management level and predicted 22 resource outputs. They estimated that current (1970) AUM production is 222 million animal unit months and that investments already made in range practices would have an annual cost of $938 million.

Next a series of linear programming (LP) runs were structured around two variables—production levels and constraints on land use. Each LP solution gave a least-cost investment and land management solution for achieving a goal. It was felt that one solution would have little if any value by itself. The philosophy exercized in this effort is that several series of solutions will produce evidence of the interrelationships within the whole range system as it reacts to alternative assumptions, policies, and demand levels.

Results revealed that wood output seemed to decrease surprisingly little as grazing levels increased. On the other hand, storm runoff and sediment increased with higher grazing levels. The results also indicate that:

1. Shifting production, according to the trends shown by optimal solutions, offers opportunities for achieving AUM goals more efficiently.
2. These efficiency gains would be accomplished by (a) using less acres but managing them more intensively and (b) obtaining larger relative shares of production from the East and South.
3. Such shifts in production would be accompanied by improvements in concomitant products and environmental values.
4. The current share of Forest Service grazing is generally consistent with results from the model and can even be increased modestly, on a competitive basis.

Conceptualizing Environmental Policies for the Development of Natural Resources

R. G. F. Spitze and W. D. Seitz, University of Illinois

In this paper a theoretical analysis is presented designed to add to the conceptual framework for dealing with environmental problems and thereby provide an improved basis for public decision-making and empirical research. Emphasis is on the variables affecting perceptions of the environment by the individual and by groups, for it is their perceptions upon which problems are formulated and both private and public actions taken. The public decision-making model is that of a democratic, representative political system involving the four policy developmental steps of problem identification, public awareness, alternative proposals, and public action and consequences.

The first conceptual relation concerns an individual's perception of environmental problems. Perceptions about these problems, either generally or as a specific attribute, are related to three variables: (1) physical condition of the environment, (2) man's knowledge of the environment based on both reliable understandings and fantasies, and (3) man's values. The individual's index of the degree of the problem characterizing the environment reflects his perceptions of the environment.

The knowledge variables are defined quite broadly, including all the individual knows about the environment, both reliable and unsupported. The effect of values on an individual's perception of the environmental problem depends on the sum of his experiences, as evaluated, including past knowledge.

The three classes of perceived environmental problems that may precipitate action are (1) change in the environment from its "natural" state resulting from productive activities undertaken to satisfy wants; (2) externalities, spillover effects, or third party effects; and (3) the ability of the world to support the current levels of economic growth.

After problem identification in public policy development comes public awareness. The rapid spread of concern can be traced to several factors: dissemination of knowledge by news media; rising levels of living; emergence of special interest groups concerned with the quality of the environment; and growing concern of many individuals that ecological systems are being permanently threatened.

The next step is the identification, refinement, and compromise of alternative proposals for problem solutions. These proposals will become rallying points for crusades or counter-interest groups. The approaches appropriate to environmental problems include reorganization or establishment of administrative bodies, prohibition of certain activities, subsidizing others, taxation of effluents, development of new technology, etc.

In the final stage of public action and consequences, public policy-making moves to the legislative, executive, or judicial branches and a decision emerges from the interaction and compromise among the several public decision-makers, each influenced by the individuals represented and the advocacies of existing pressure groups. Public action is conceived as a function of the individual decision-maker's adjusted environmental problem index, his adjusted view of the competition for resources, his adjusted values concerning the desired mix between public and private policy, and the solutions among which he has to choose. The essential difference between this and the functional relationship representing the private individual decision-making is the explicit recognition of the wishes of the constituency.

The environmental crises surely seem destined to continue to generate difficult, value-laden research problems and public policy choices.

Measurement of Nonmarket Resource Values

Daniel R. Talhelm, Michigan Department of Natural Resources

Efficient use of natural resources requires that nonmarket values as well as market values be fully considered when assessing alternative uses. This paper illustrates how nonmarket outdoor recreational uses of natural resources may be evaluated on the same basis as market goods. In addition recreation supply is defined, a framework for simultaneous analysis of various qualities of creation is presented, and calculation of marginal benefits of quality changes and location changes is analyzed.

In market exchanges goods are explicitly traded for money or other goods. Demanders may incur other expenses in addition to the market exchange price, such as for transportation and for time taken from other activities. While all types of costs weigh proportionately in demanders' minds, demand analysis usually abstracts from all costs but purchase prices because they are the essence of information needed for comparison with supply. The same is true with respect to nonmarket outdoor recreation resources, except that the observed market price is zero and the cost of time is usually very high. Hypothetical market prices and consumption must be analyzed to compute net willingness to pay.

To each individual the short-run supply of homogeneous visits to any recreation site appears perfectly elastic (horizontal) because he may make "any" number of such trips to the same site at the same price. Given the distance and the total length of time to be included in the trip, all such trips are available at a constant price given by the "price function."

Residents of each location face a unique set of prices for various recreation alternatives. Their demand for the alternatives is a function of the price of each.

Two recreation sites offering recreation of the same quality are likely nearly perfect substitutes. The supply of that quality for any individual is defined by the price of the least expensive, or closest, recreation site of that quality. Consumers are not likely to pay a price to use a given site if a perfect substitute is available at a lower price.

We may define the quality of recreation by observing the quality definitions for which the most users visit only the least expensive site of each quality. For trout streams in the southern Appalachians, catch rate, fishing regulations, and stream size were the most important determinants of angling quality.

While the demand curve for a quality of recreation may have the usual continuous slope, the willingness of users to pay for that quality of recreation at a given site drops sharply at the level of price where a perfect substitute is available at the same price. Thus the demand curve for a given quality of recreation observed may be a poor indicator of total value.

A change in recreation quality at a site might best be viewed as the destruction of the old quality and the creation of a new quality at that site because the value lost and the value gained depend upon the locations of substitutes.

An Econocological View of Environmental Quality

Harold B. Jones, Jr., Economic Research Service, USDA

Environmental quality is a pervasive and all-inclusive topic, more relevant than in any other time in history. The goals of society are moving from an economic to an ecological framework. This paper is concerned with economic ecology, i.e., economics in an ecological perspective. It is an attempt to integrate economic and human ecology in a world that is increasingly dominated by man's organizations and institutions rather than nature's forces. Solving the environmental problem involves a balancing of costs and returns to achieve some level of optimum satisfaction for society. The nature of this economic balance point is examined, as well as some of the social and cultural factors that determine where man's productive activity will reach an equilibrium with the environment.

Traditional concepts of ecology emphasize interactions within the biotic system. These concepts can be blended with human ecology to form the basis for an ecological complex in which human activities and social organizations are recognized. Within this complex the key ingredients for change are the struggle for survival and competition among plant and animal populations. The unintended consequences of this competition and consumer demand for a higher standard of living have created the environmental problem. Man's attempt to alter and manipulate nature has upset the "natural" balance of the ecological system.

This problem can be viewed as a form of economic balance:

$$\text{Quality of life} = \frac{GNP - MC}{P} + \frac{IB - ED}{P}$$

where GNP = gross national product; MC = monetary cost; P = population; IB = intangible benefits; and ED = external diseconomies. The first segment of the equation represents the private market sector of the economy. The second segment represents the intangible net benefits of economic activities in a particular social and cultural environment.

When the aggregate disutility of man's activities become great enough to offset the aggregate benefits, there will be pressure created to change some part of the system. These changes will create higher costs in the private sector and may ultimately lower the aggregate benefits from a given level of production. The point at which these changes take place will be determined by certain social and economic factors within the ecological complex.

Five broad factors that will influence the level of environmental quality are discussed. They are (1) geographic environment, (2) family-kinship systems, (3) planning horizon, (4) type of economic system, and (5) value system. It can be concluded that if the institutions of man are to produce maximum benefits for society with minimum damage to the environment, it will involve not only a reappraisal of technology but also a reassessment of the role of sociocultural influences in the ecological complex.

TAXATION AND AGRICULTURE

PROGRAM ORGANIZER: PHILIP M. RAUP, UNIVERSITY OF MINNESOTA

The Impact of Selected Tax Provisions on Agricultural Investments and Management*

HOY F. CARMAN

A NUMBER of studies have examined the impact of various income tax provisions on agriculture, but new legislation and changing tax rate structures can alter their conclusions. The Tax Reform Act of 1969 includes several provisions affecting agriculture and is the focus of this paper. Topics examined include the impact of (1) new tax provisions on tax-sheltered investments in breeding livestock, orchard development, and land improvement; and (2) changes in tax rates on economies of scale and farm size.

Raising beef-breeding cattle, a popular agricultural tax shelter, was an obvious target of tax reform. Examination of a budgeted example shows, however, that these investments continue to be profitable when conducted on a small to medium scale. Tax reform decreased after-tax profits 31 percent for taxpayers in all brackets. As before reform, the tax advantage is greatest for high income investors.

Provisions requiring capitalization of all expenditures for purchase, planting, cultivation, maintenance, and development within four years after planting destroys the tax shelter advantages of citrus groves and almond orchards. Other orchard developments, conducted on a small to medium scale, are not affected by reform provisions. Comparison of almond orchard development costs before and after tax reform provides an estimate of the tax subsidy formerly available. As with cattle, high-income investors received the largest subsidy. Similar subsidies now exist for other perennial corps, regardless of their profitability as a tax shelter investment.

Recapture provisions on soil and water conservation and land-clearing expenditures, combined with interest limitations, will curtail tax-motivated investments in improvement or reclamation of farmland. Congress now appears to be saying that land conservation is desirable only if ownership does not change within 10 years.

The abolition of profitable tax shelter investments in citrus, almonds, and land improvements will shift investor interest to other crops and activities or to nonagricultural investments. In California there seems to be increased interest in developing pistachios, walnuts, wine grapes, and kiwi fruit as tax shelters. Continued development subsidies raise questions concerning conflicts in policy; for example, tax subsidies are available for establishing cling peach orchards at the same time the industry is conducting a green drop and tree removal program under a state marketing order.

An empirical cost function for large field crop and vegetable crop farms in the Imperial Valley, California, is used to demonstrate the impact of decreased federal income tax rates on optimum farm size. Given 1962 tax rates, net returns to management are maximized by expanding farm size to the 1,250–1,750 acre range and investing any excess funds in tax-free bonds rather than farming. Decreases in tax rates, fully effective in 1972, change this conclusion. Within the range of farm sizes considered, the operator maximizes management returns by expanding farm size to the maximum (4,500 acres). Thus, decreased tax rates tend to increase optimum farm size and increase after-tax returns to management. Debt financing continues to be an attractive method of expansion.

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* Abstract.

HOY F. CARMAN *is assistant professor of agricultural economics and assistant agricultural economist in the Experiment Station and on the Giannini Foundation, University of California, Davis.*

Discussion: Harvey Shapiro, Office of Tax Analysis, U. S. Treasury Department*

My major criticism of Carman's paper is its focus and presentation. I think he has run two themes together that would have been more appropriately treated as wholly separate topics in separate papers. While the bulk of the paper is concerned with tax reform the introduction led me to believe the paper would be concerned with farm management. And, more basically, while Carman does refer to the term "tax-sheltered investments" his paper gives little attention to the specific limited ways that the new law defines abuse or, more generally, to the overall question of what is an abuse.

The blurring of the lines between tax reform and tax considerations in farm management has contributed to the misunderstandings in the area of farm taxation and has handicapped recent reform efforts. Agricultural economists interested in tax matters may produce some material of interest for farm management purposes, such as the optimum strategy for herd management in the light of the capital gains provisions. The experience of the 1969 deliberations suggests this has relatively little relevance to tax legislative deliberations. What Congress was basically concerned with was the conjunction of large farm losses and large nonfarm incomes. The important and largely unanswered questions in the 1969 deliberations were: (1) How important to agriculture are the tax-induced investments which run into the hundreds of millions of dollars? (2) What is their effect on farm real estate values, especially ranchland and orchards? (3) What effect has it had on the price of beef in the supermarket? (4) What effect has it had on farm income? There is of course the basic question: Why provide differential treatment for agriculture by providing cash accounting? If farmers are sufficiently astute to take account of some rather complex tax provisions in their operations, as Carman suggests, they are astute enough to be treated as all other businesses and required to go to accrual accounting.

The recent tax changes, apart from those directed toward citrus and almonds, will have little effect because they do not affect (1) people who made money from farming regardless of their other income, (2) people who reported large tax losses from farming if they did not have big other incomes, and (3) people who reported small tax losses from farming no matter what their other income. Those who presumably would be affected by the Excess Deductions Account provisions can avoid this tax net entirely, according to a recently published article, through the use of a Subchapter S corporation.

* Views expressed are the author's and not necessarily those of the Office of Tax Analysis or of the Treasury Department.

A New Look at Farm Property Taxation*

Frederick D. Stocker

The local property tax is undergoing changes that have far-reaching implications for agriculture. On the one hand it is becoming less *local,* in the sense that the public services its revenues support (notably schools) are coming to be recognized as matters of statewide or even national concern. Local financing through the property tax thus is becoming anachronistic. Continued decline in the relative importance of local financing, especially through the property tax, is likely to continue.

On the other hand the property tax is becoming less an impersonal *ad rem* tax as liabilities come to depend more and more on who owns the property, what he is doing with it, what his income is, and his age. Preferential assessment of farmland is one manifestation of this trend. Senior citizen exemptions is another. The property tax "circuit breaker" is the best device for "humanizing" the property tax. Unfortunately the circuit breaker approach tends not to offer relief to farm taxpayers, as its benefit is limited to residential property taxes.

Agricultural economists can contribute to progress in the area of property taxation by analyzing and quantifying the nonlocal benefits from traditional local property tax supported functions (such as schools) and by working out ways of applying the circuit-breaker principle to farm property taxes.

* Abstract.

Frederick D. Stocker *is professor of business research and public administration at The Ohio State University.*

Discussion: Leo Cohen, Southern Illinois University

The property tax has been and continues to be an extremely important source of revenue to local governments and especially school districts. This tax, which is poorly administered and highly regressive, is nevertheless very productive and affects most economic groups, including agriculture.

During the past 15 years roughly one-half of the states have enacted laws that grant preferential treatment in the assessment of agricultural or open-space land. These laws essentially provide for the assessment of farm land at its agricultural use rather than its highest or best use. Most states fail, however, in the goal of achieving desirable land-use patterns, except in those few states where there is a further mechanism to provide this discriminatory treatment consistent with a well-defined plan.

There seems to be a trend for greater involvement by the state and federal governments in creating a more unified federal-state-local fiscal system, more consistent it is hoped, with objectives of our society. Revenue-sharing has been somewhat responsible for stimulating much of the current thinking and proposed legislation on this subject. In any event it seems very likely that a more integrated revenue structure will result and that the property tax will diminish in its quantitative importance to local governments and will be more equitably administered.

PROGRAM ORGANIZER: JAMES S. PLAXICO, OKLAHOMA STATE UNIVERSITY

Future Structure of Census Data Relating to Agriculture and Rural People*

CONRAD TAEUBER

THE assertion that our statistical definitions are in need of adjustment to bring them into alignment with the realities that they purport to measure is hardly new. In 1944 I was a junior author of a paper [1] in which it was argued that the available gross statistics did not adequately meet current needs. That paper proposed a "few simple, distinct and clearly recognizable classes, and a tabulation for each of these classes of such data as are needed for recognizing and understanding the problems related to them." Economic Class of Farm is the present-day response to that suggestion. There is little dissent from the view that such a scheme of classification has significantly increased the utility of the statistics and has provided a basis for many useful analyses. Nevertheless there continues to be widespread use of the gross number of farms, and it is frequently used as a divisor to arrive at averages per farm even though knowledgeable analysts know full well that American agriculture in 1971 is far too diverse to be categorized in that manner.

I am expressing a personal opinion, one not adopted by the Bureau of the Census or other government agencies that deal with agricultural statistics. It has been discussed within the Government, with a committee of the American Agricultural Economics Association, and elsewhere; and many persons have expressed similar views.

The time has come for reevaluation of the concepts that underlie the statistics collected in the Census of Agriculture and similar data-collecting and publishing activities. The present concept includes a large number of units that make little contribution to total agricultural production and have little relevance to agricultural programs. To the extent that the individuals and families involved with these small units present problems affecting the public welfare, these are not problems within the framework of agriculture and the data needed for planning programs should be derived through other sources, primarily the census of population. If, as has been projected, 90 percent of the agricultural production in 1980 will come from between 500,000 and 600,000 units, there would seem to be little purpose served in maintaining a concept that might lead to a finding that there are 2 million farms at that time. Statistics of industrial production omit the products of establishments that have no employees, and those of retail trade omit enterprises with annual sales of less than $2,500. The activities of these small enterprises cannot affect trends in the overall totals. The functions they perform are less economic than human and social. In this respect modern American agriculture is not much different.

As agriculture becomes increasingly commercialized the traditional distinction between agricultural operations and farm residence loses much of its former meaning. To the extent that it is needed, information concerning persons related to agriculture directly or indirectly should be collected through the Census of Population and through sample surveys. The farm residence concept could usefully be replaced with a concept of residence that distinguishes compact settlements from those that are dispersed.

* Abstract.

CONRAD TAEUBER *is associate director of the Bureau of the Census, U. S. Department of Commerce.*

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Implications of the Census for Agricultural Statistics*

HARRY C. TRELOGAN

ECONOMISTS have a responsibility to provide a relevant theoretical framework for data collection by public statistical services. Agricultural statistics users agree changes are needed in farm definition, criteria for economic classification, and especially in the conceptual framework to comprehend interrelationships among the several sectors in the agricultural economy. The consensus deteriorates rapidly, however, in consideration of specific proposals.

The present farm definition is all-inclusive. Taeuber's proposal for a cutoff at $5,000 gross sales would have a major impact on USDA's statistical series and also on program operations. The consequences need thorough evaluation.

With SRS's shift to probability sampling, use of census data for benchmarks is no longer essential for current estimates of major crop and livestock items. Continued dependence is placed on census benchmarks for minor crops and for county and other small-area data.

USDA has been devoting increased attention to questions concerning the structure of agriculture. Recent studies include one contracted with Dick Foote, entitled "Concepts Involved in Defining and Identifying Farms," and Eldon Weeks' report of "Aggregate National Agricultural Data—Status and Alternatives." Further, a committee has been appointed by Don Paarlberg to review the question of farm definition. Several alternatives and the implications of each are under study.

A broader distribution of agricultural economic data sources, to include the entire family of economic censuses, is a necessity for the future. Perhaps 1974 would be a good year to test census procedures for covering all establishments that are engaged in agriculture-related business activities. Early development of the conceptual framework for such coverage would be a big step forward.

* Abstract.

HARRY C. TRELOGAN *is administrator of the Statistical Reporting Service, USDA.*

The Data Problem in Agricultural Economics Research*

ELDON E. WEEKS

AGRICULTURAL economics researchers have done their jobs well and are now wandering away from the heartland of traditional efforts. This expansion of issue scope and involvement, along with expansions in public sector activity, would seem to indicate some possibilities for reexamination of theory and methodology on the one hand and some new perspectives for the detection of research problems in commercial agriculture on the other. Appropriateness and availability of data have also played a role in distributing research efforts among problem areas. As changes have occurred in agriculture and as we have mined the easily available data, there are residual groups of problem areas, as well as emerging issues, which require inputs of data not easily available in the past. Resources required for producing these data are too massive for individual researchers and research teams to muster for their own use. Enough change has taken place in agriculture and in the scope of agricultural economists' research attention that such basic matters as redefinition of universes and institutions are at issue.

Some of the issues in which data limitations for research are severe are found in regional and national aggregative aspects of agriculture, component share structures, and characteristic distributions, and at the interfaces of agriculture and other sectors. Data and accounting systems that would allow better coordination and aggregation of research efforts are badly needed to obtain greater cumulative properties in the outputs resulting from research resource commitments.

* Abstract.

ELDON E. WEEKS *is with Economic Research Service, USDA.*

Adequacy of Economic Statistics for Agribusiness Planning*

Charles E. Erickson

Knowledge is essential to progress. The fact gathering and disseminating programs of various U. S. governmental agencies are probably key factors in establishing this country in its current position of world prominence in efficient production and marketing of agricultural and industrial products.

Adequacy of economic statistics, however, implies more than just quantity; quality considerations must also be taken into account. Unfortunately, recent efforts by USDA and the Department of Commerce to improve quality have frequently been at the expense of quantity. Regional estimates of crop and livestock production are a case in point. Another is embodied in the suggestion that the Census of Agriculture should exclude from its farm count all farms with less than $10,000 sales. In the latter instance some states would virtually be eliminated from the farm number tabulation.

Agribusiness planning requires detailed knowledge of supplies of commodities as well as demand factors, including livestock and poultry numbers and people. Lack of knowledge is likely to result in economic waste, which in the long run is borne by the public. Although accuracy is important, perhaps too much emphasis is currently being placed on it with too little consideration for user's needs for quantity and detail. Researchers in government, universities, and business should make known their needs to both USDA and the Department of Commerce who have evidenced a willingness to accommodate legitimate requests for more as well as better data.

* Abstract.

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IMPACT OF INFLATION ON AGRICULTURE

PROGRAM ORGANIZER: B. F. STANTON, CORNELL UNIVERSITY

The Distribution Among Agricultural Producers, Commodities, and Resources of Gains and Losses from Inflation in the Nation's Economy*

G. E. BRANDOW

INFLATION during 1953–1970 was partly demand-pull and partly cost-push. Surges of inflation lifted farm and retail prices of meat, poultry, fruits, and vegetables. Price increases of livestock and poultry tended to be checked by expansion of output made possible by large stocks of feed grains and the availability of diverted acres. In light of excess capacity, prices of major crops were little affected by inflation; changes in government programs sharply reduced wheat and cotton prices. Price supports for tobacco and dairy products were raised.

Inflation increased prices paid by farmers. Real estate taxes and farm wages were strongly affected, in addition to upward trends. The combined effect of changes in prices received and paid on total net farm income is unclear, but apparently net income rose no more than the farm cost of living and perhaps less.

Farm wealth rose during the period, mainly because of a strong advance in farm real estate prices. The major part of the increase apparently occurred for reasons other than general inflation, although inflation had an effect through imputed returns to farmland and in many areas through value for nonfarm uses.

Inflation depressed net incomes realized from feed grains, wheat, and cotton, compared with net incomes realized from meat animals, poultry, fruits, and vegetables. Probably inflation slightly eroded the competitive position of large-scale farms compared with that of commercial family farms, for the large farms use much hired labor and machinery, both inflation-sensitive. Data on cash rents in the midwest suggest that much of increased farm income in the 1960's went to landlords; probably this was less true under crop share leases. Off-farm employment opportunities and earnings of some noncommercial farm families were improved by economic conditions usually associated with rising prices, but families not in the job market (e.g., elderly persons) were pinched by the rising cost of living. Hired farm workers on the whole gained from inflation. The effect of inflation on the poor depends on who the poor are.

As size of farm increases, real estate (moderately inflation-sensitive) increases as a share of total assets; financial assets (mostly not inflation-sensitive) decrease. A higher proportion of debt gives large farms more 'leverage." Thus owners of large farms are in a better position to gain from asset appreciation due to inflation than owners of small farms, but the extent to which ownership of large farms is vested in operators or in landlords is not shown by available data.

Agricultural resource use has been dominated by long-run adjustments to technological and market changes and by government programs. Resource malallocation attributable to inflation has been minor in comparison. Most of the historic advantages of inflation (typically demand-pull) to farmers diminish or disappear in cost-push inflations. Inflation seems likely to persist and to be more nearly cost-push than in the 1950's and 1960's. It will be damaging to agriculture.

* Abstract.

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The Impact on Net Farm Income of National Inflation*

Luther Tweeten and Leroy Quance

Trends in national inflation and prominence of the cost-price squeeze in explaining economic problems of farmers prompted this study. The study traces the effect of national inflation on the parity ratio through to net farm income, using static and dynamic techniques.

Any increase in aggregate demand for farm output stemming from national inflation appears to be completely offset by higher marketing margins, and there is no basis to reject the hypothesis that national inflation has no exogenous impact on prices received by farmers. But each 1 percent increase in national inflation raises prices paid by farmers .6 percent in the short run and 1 percent in the long run.

A 10 percent increase in prices paid by farmers for items used in production (including interest, taxes, and wage rates), stemming from national inflation, reduces farm net revenue 12 percent in the short run and 3 percent in the long run. The supply response dampens the impact of input-price inflation on the parity ratio: it offsets 19 percent of input-price inflation in about 2 years and 40 percent in many years. The supply response even more effectively offsets the decline in net income. Adjustments made by farmers offset 30 percent of the impact of input-price inflation on net farm income in the short run and 80 percent of the impact in the long run.

The impact of inflation is by no means homogenous among inputs. Price inflation for cash operating inputs with an elastic demand such as fertilizer tends not to disadvantage farmers. On the other hand, use of real estate, labor, and durable inventories is relatively unresponsive to higher taxes, wages, and interest rates. The result is that farmers are seriously disadvantaged economically by inflation of these input "prices." The differential impact of inflation reconciles the seeming paradox of simultaneous calls for a tax on fertilizer and for wage and interest controls to benefit farmers.

Farmers benefit from input price increases if the price elasticity of demand for the input exceeds that of the output. Thus farmers benefit from higher prices of several cash operating inputs purchased from the nonfarm sector. They do not benefit from higher interest, taxes, and wage rates, nor from higher prices for the aggregate of all purchased inputs. The analysis suggests that farmers would do well to turn their traditional concern with exploitation by nonfarm industry to an imminent concern with the really prominent sources of debilitating inflation—institutions that establish taxes, interest rates, and wage rates.

The simulation model predicts a rise in the parity ratio from 74 (1910–1914 = 100) in 1969 to 78 by 1980 with a continuation of present government programs and no inflation but a decline to 59 in 1980 with 4 percent annual inflation. The farming industry can maintain net income and even adjust to a free market by 1980 with 2 percent annual inflation in input prices. But with high rates of inflation the farming industry is destined for hard times. Major adjustments in government or farmer-run programs will be needed to avoid severe financial troubles for farmers if inflation continues at its 1970 rate.

* Abstract. Oklahoma Agricultural Experiment Station Journal Article 2346. Estimates and views expressed are those of the authors and are not official estimates or views of the U. S. Department of Agriculture.

Luther Tweeten *is professor of agricultural economics at Oklahoma State University* Leroy Quance *is agricultural economist, Natural Resources Economics Division, Economic Research Service, USDA.*

Discussion: Lowell D. Hill, University of Illinois

The paper by Tweeten and Quance focuses almost exclusively on changes in prices of farm inputs. From a two-variable single-equation regression model they conclude that "national inflation exerts no exogeneous impact on prices received by farmers." Interpreting inflation in the context of market rigidities suggests that other sectors of the economy may experience real income effects that would shift the demand for agricultural products.

The Tweeten-Quance conclusion that farmers should shift their concern from exploitation by nonfarm sectors of the economy to institutions that control taxes, wages, and interest is based on their results showing a low-income response coefficient but a large historical change in prices.

However, net farm income is more responsive to changes of other inputs, as shown by their regression analysis. Policy recommendations for farmer action should be based on the probability of success in manipulating the institution and on the income response, if successful, rather than on historical changes that were mostly outside farmers' influence.

The conclusion in the Tweeten and Quance paper, and to a lesser extent in Brandow's paper, is that inflation is bad. Such a conclusion needs further qualification. Demand expansion, full employment, rising real incomes, and increasing GNP are usually desirable goals whose attainment is closely related to the same monetary and fiscal policies that control the rate of inflation. We can find evidence of lower rates of mortgage foreclosures, bankruptcy suits, etc. in periods of inflation than we find in depression. Property tax increases often lag behind increased incomes and property values. Periods of national prosperity are usually accompanied by higher standards of living for rural as well as urban populations. Migration of excess labor out of agriculture is positively correlated with levels of national employment.

Obviously not all of these variables can be incorporated into a single model, but the overall goodness or badness of inflation should be evaluated on more than the correlation between general price levels and prices of specific inputs.

Discussion: GENE L. SWACKHAMER, Farm Credit Administration

Brandow sets the stage well, acknowledges the significant role of government programs in influencing farm output, and tends to dismiss econometric analysis because of the many complexities. But, like any good economist, he seeks to test his intuitive hypothesis about commodities and inputs and the data and models available, regardless of the complexities. Using regression analysis he demonstrates a positive association of inflation with the prices of selected products and inputs (except fertilizer).

The contrasts between his equations including and excluding time illustrate the importance of trend on multiple correlation and regression coefficients. Because of the uncertainty of causality in the time proxy, care must be exercised in interpreting these price relationships. Just as Gordon [2] has shown that unemployment dispersion and disguised unemployment have helped cause the Phillip's curve to shift to the right in the 1960's, agricultural economists must be especially alert to the components of trend that may cause enduring changes in product and input price relationships with subsequent farm policy implications.

An interesting similarity develops between Brandow's finding that a .6 percent change in the parity index is associated with a 1.0 percent change in the BLS index of industrial wholesale prices and Tweeten and Quance's .6 percent increase in the parity index associated with a 1 percent increase in the implicit price index (IPC), the GNP price deflator. Inasmuch as the IPC is a derived index of implied average price relationships weighted by the relative share of GNP components in contrast to CPI and WPI fixed weight indexes of measured prices, some experimentation with other inflation indexes might prove informative,[1] especially since the IPC has persistently increased at a faster rate than many other price indexes.

Brandow's attempt to explain farm real estate price changes contributed little. Other more exhaustive efforts, including those by Tweeten and Nelson [4] and Bickel [1], have shown that "other" factors swamp the effects of changing productivity and average net farm income. Had net farm income been examined by farm size as measured by sales class, I believe it would have shown statistical significance.

In general Tweeten and Quance agree that agriculture is disadvantaged by input price inflation, but they demonstrate some interesting results which show that farmers benefit when the elasticity of demand for farm output is low relative to elasticity of demand for inputs. In their estimates of national inflation on farm prices, the rationale for a nonsignificant short-run coefficient for prices received lays the groundwork for the conclusions that (a) inflation has a real price effect on the parity ratio and (b) some input price inflation can enhance net farm income.

The interaction of different cumulative rates of inflation and different demand elasticities

[1] For a good description of price indexes and inflation see [3].

should be examined further. In view of the relative modest annual change in the parity ratio (1969: 74; 1970; 72; 1971: 70p) over time, and especially since 1966 under rising levels of inflation, the projections to 1980 imply that agriculture might be on an income precipice. This would especially seem so since the model assumes continuing present government farm programs and a continuing trend of nonprice shifts in supply and demand.

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The President's Departmental Reorganizational Program, with Special Reference to Agriculture

PROGRAM ORGANIZER: DON PAARLBERG, U. S. DEPARTMENT OF AGRICULTURE

Discussion: WILLIAM A. CARLSON, Office of Planning and Evaluation, USDA

IN his State of the Union Message, the President announced plans for a "New American Revolution" to improve the efficiency, effectiveness, and responsibility of government at all levels. The President's package of reforms includes decentralization, management, assistance to state and local governments, streamlining federal loan and grant procedures, a new Federal Executive-Service, revenue sharing, and reorganization.

The President's Departmental Reorganization Program (PDRP) was sent to Congress on March 25. There are four bills establishing four new departments: Department of Natural Resources (DNR), Department of Human Resources (DHR), Department of Community Development (DCD), and Department of Economic Affairs (DEA). Seven existing Departments (Agriculture, Interior, Labor, Commerce, HUD, HEW, and DOT) and several independent agencies would be abolished and their functions transferred to the new departments.

The Department of Agriculture would have functions transferred to each of the four new departments. The DNR would get Forest Service, Soil Conservation Service, and some research. The DHR would inherit Food and Nutrition Service, food inspection from Consumer and Marketing Service, and some research. The DCD would get Rural Electrification Administration, Farmers' Home Administration housing, and water and sewer loans and grants, and some research. The DEA would receive all remaining USDA functions and would be the focal point for policies and programs dealing with commercial agriculture, both domestic and foreign.

Farmers oppose abolishing USDA but could benefit from the reorganization in several ways. As citizens and taxpayers they would benefit from overall improvement in government efficiency, effectiveness, and responsiveness. As rural residents they would benefit from improved government performance in meeting the needs for natural resources development, environmental quality, and accelerated economic and social development of rural communities. As producers of agricultural commodities they would benefit by participating as equals in a Department of Economic Affairs that would be better able to find effective solutions to complex, highly interrelated, economic problems that can no longer be dealt with through present client-oriented departments.

Discussion: HYDE H. MURRAY, Associate Counsel, Committee on Agriculture, U. S. House of Representatives

Can there be a substantial reorganization of the Federal Government in this Congress? How about the U. S. Department of Agriculture? Will it change?

The President, in recommending four new "super-agencies," addressed himself to the very real "confidence crisis" that exists today. The urge to be responsive to a changing America and a changing agriculture seems to be the strongest suit in the President's hand. And he has not played his cards badly so far. Rather than use the mechanisms of the 1949 Act, he chose to propose in order to let Congress dispose.

That process is going on now. It is slow and deliberative. The House Government Operations Committee has held extensive hearings on the overall picture. Hearings are scheduled to continue in September on the specific Community Development proposal. Natural Resources is expected to follow. Prospects are that the House Government Operations Committee will approve a formulation of the Department of Community Development.

In the Senate preliminary hearings have been held, and the first agency proposal being considered is the Natural Resources Development; but Senate progress is less rapid than in the House.

The tone of the testimony relative to the overall proposals has been favorable. However, the proposal to fragment USDA has been criticized by members of Congress of both parties.

While the prevailing sentiment among the agricultural leadership is presently averse to the concept of abolishing USDA, it is Murray's view

that in the long run—perhaps next session or next Congress—there will be basic changes in USDA missions although probably not as sweeping as envisioned by the Ash Council.

Those who fear these changes should take solace in the fact that agriculture is too important and too big in all of its ramifications ever to be ignored. It would be impossible to attempt to throttle legitimate efforts to articulate the farm and rural point of view in the councils of government.

Discussion: Mark T. Buchanan, Western Regional Agricultural Experiment Stations

A major segment of the President's Reorganization Plan has to do with upgrading information gathering, retrieval, and manipulation; with improving personnel and program management; and with other proposed additions to management and analytical capability. Potentially these changes can be a greater force for "good" or "bad" than all the other parts of the plan combined. Of course one's perception of good or bad depends on one's objective, perspective, and values.

In the continuing power struggle, the right information at the right place at the right time can be a determining influence. Power follows knowledge. I think this is good because the use of better information prepared from the points of view of the numerous participants in the political process can result in sounder decisions than before.

Increased reliance on information and analysis can be helpful (1) in improving planning; (2) in making decisions on the major issues and programs to be financed to what level by government; and (3) in the selection of implementing procedures.

From my perspective the long-run solutions of problems of agriculture and rural people as well as those pertaining to the contributions these sectors can make to the general public are to be found primarily within the economy, society, and political economy as a whole. As Ted Byerly once said, "Even agriculture has moved off the farm." So likewise have the solutions to most problems relating to farm and rural people. New alignments are needed.

For these and other reasons I favor the concept of governmental and Congressional reorganization. Especially as it relates to science and education, however, the President's plan should be modified to take advantage of the full range of competencies available within the state agricultural experiment stations, extension services and their parent institutions.

Discussion: Robert N. Hampton, National Council of Farmer Cooperatives

Farm and farm-related groups have a special concern over the possible impact of reorganization on their effectiveness in having their special views and interests heard and recognized in government circles. Farm leaders have warned that reorganization could lead to reduced efforts on farmers' behalf, to lowered farm income, and to the disintegration of the family farm structure through takeover by nonfarm interests.

Among specific concerns about the consequences of reorganization for agriculture are those expressed by Kenneth Naden, Executive Vice President, National Council of Farmer Cooperatives: "The proposal sounds attractive in some regards . . . but the fact remains that this action could alter the policies of the Treasury Department and Internal Revenue Service on the tax treatment of farmer cooperatives and change the attitude of the Department of Justice in its antitrust policies for farmer cooperatives." The National Council and other agricultural groups have also feared that such reorganization would result in even greater political pressures for lower food costs in ways that might be detrimental to farm income.

Acknowledging that farm fears may be overemphasized in the initial reactions of agricultural leaders, we should look carefully at the major arguments advanced for reorganization. Roy L. Ash, chairman of the President's Advisory Council on Executive Organization and president of Litton Industries, has reemphasized in a recent statement to the Senate Committee on Government Operations that the central goal of more efficient government management can be achieved without more centralization, even though larger departments would be involved.

Because of the critical concerns of many groups, including Congressional committees and middle-echelon bureaucrats, the battle over reorganization is likely to be hard-fought and extended. Unless the President is willing to expend a tremendous portion of his chips on this effort many perceptive Washington observers believe that odds are strongly against major reorganization within the medium-range future.

FIRST AWARD PAPER IN THE UNDERGRADUATE STUDENT ESSAY CONTEST

The Economic Feasibility of Aquaculture*

GARY A. GILBERTSON

The goals may seem beyond our reach, but our reach extends daily.

—Spilhaus [12, p. 69]

THE U. S. freshwater fishing industry is beset by severe economic problems. The annual value of the catch from the Great Lakes, a primary source of U. S. freshwater fish, declined from $10.8 million in 1950 to $6.1 million in 1969 [16]. The commercial catch of wild catfish also has declined sharply in recent years [15]. The decline in the value of the freshwater catch can be attributed to several causes: overfishing, sea lamprey invasion of the Great Lakes, industrial and agricultural pollution of streams and lakes, thermal pollution, and increased foreign competition.

Aquaculture is the art and science of cultivating or propagating water-dwelling organisms in a controlled environment [7, 8]. Interest in aquaculture as an alternative way of obtaining fish supplies has increased as the commercial catch of freshwater fish has declined. The technique is often cited as a highly efficient means of increasing food and protein production to relieve pressures on the food supplies induced by population growth [7, 11]. In today's ecology-conscious society, enthusiasm about aquaculture also has developed because it represents a possible economic use for the heated waste water discharged from electric power generating plants. This large source of heated water might be used for producing fish in the Great Lakes region, where up to now fish raising has not been profitable because cool temperatures have produced short growing seasons and low fish growth rates.

Whether aquaculture will realize much of its economic potential is not known with certainty. Most studies to date have focused on the engineering and biological aspects of aquaculture. Consequently, little information is available on costs and returns from aquaculture and the demand for increased fish production from aquacultural facilities. This essay examines a few of the crucial questions concerning the economic feasibility of aquaculture.

Potential Production from Aquacultural Facilities

Catfish and trout currently account for a relatively large percentage of all fish raised in U. S. freshwater aquacultural facilities. About 80 percent of the total U. S. production of pond-raised catfish are raised in the central Mississippi Delta region which includes parts of Arkansas, Mississippi, and Louisiana [10, p. 2]. Catfish and minnows were raised on about 64,000 acres of land by 1,525 farmers in 12 southern states surveyed by the U. S. Commerce Department in 1968 [15].

A U. S. Department of Interior study reports that catfish production is expected to double over the next few years, with extremely large increases possible over the long run [15, p. 31]. The amount of increase will depend partly on the success of research underway on rearing catfish in intensively stocked tanks (rather than in ponds), genetic improvements to develop catfish that grow rapidly and at nearly the same rate,[1] disease control, and parasite control. The overall aim of this research seems to be to aid in developing a catfish farming industry similar to the poultry industry of the South which specializes in high density production within a small area [6, p. 2]. If this research is successful large production units may replace the many small catfish farms in the South.

Conventional fish farming in the South has been discussed elsewhere [4, 10, 15]. Therefore the remainder of this section of the essay focuses on an aspect of aquaculture that has received little attention: the use of power plant effluent (waste heated water) for fish raising. The heated

* Helpful comments and criticisms by Professor William D. Dobson are gratefully acknowledged.

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[1] When ponds are stocked with fingerling catfish of the same size the fish grow at sharply different rates. This lack of uniform growth creates harvesting and marketing problems.

water discharged from power plants could be used to create a warm environment similar to that found in southern ponds. The amount of fish that could be raised in the heated effluent discharged from the power plants is large. Gaucher [11, p. 148], for example, estimates that between .62 and 1.25 billion pounds of fish, or an amount equivalent to 25 to 50 percent of the total production of U. S. food fisheries, could have been produced in the heated water discharged from U. S. electrical power generating plants in 1965. Electric power use in the recent years has increased about 7 percent per year [18, p. 34]. This amounts to a doubling of power use every 10 years and a similar increase in the amount of heated water discharged into streams. For example, more than a twelvefold increase from 1970 levels in the amount of waste heat added to Lake Michigan has been forecast to occur by the year 2000 [9, p. 4]. Thus, the amount of fish that could be produced in thermal effluent may even exceed Gaucher's estimates.

Biological studies suggest that raising the temperature of a lake or stream by more than a few degrees may impair fish reproduction, make certain types of fish vulnerable to predators, or cause their death. For example, adult coho salmon die in about 60 minutes if exposed to water temperatures above 77°F [18, p. 51]. A temperature increase also may contribute to growth of undesired bacteria and algae. These and other potential dangers of thermal pollution were sufficient to cause a group who investigated pollution of Lake Michigan to recommend in 1970 that no significant amounts of waste heat should be discharged into that lake [18, p. 1].[2]

If lawmakers accept recommendations of this type, power companies will be required to replace the once-through systems now used to cool power generating facilities with cooling towers, cooling ponds, or similar devices that eliminate dumping of heated water into lakes and streams. Depending upon the system used, the facilities increase power-generating costs from about .50 percent to nearly 10 percent (Table 1). If fish could be profitably raised in connection with the cooling facilities some of the cost increase for operating the cooling facilities could be offset. Public utility commissions, which set power rates, also might encourage power plants to adopt the fish-raising facilities rather than simply allowing them to charge higher rates to cover the cost of the cooling equipment. Thus thermal pollution might be reduced without causing an increase in consumer prices for electricity.

Table 1. Cost of power generation for standard power plant using cooling system specified

Type of cooling system	Cost in mills per kilowatt hour	Cost as percent of cost for once-through system
Once-through	6.18	100.00
Cooling pond	6.21	100.49
Spray canal	6.25	101.13
Mechanical draft wet tower	6.29	101.78
Natural draft wet tower	6.37	103.07
Natural draft dry tower	6.73	108.90
Mechanical draft dry tower	6.78	109.71

Source: [17, pp. v–22].

Of course there would be fish-raising problems in connection with cooling facilities. The plants might need to carefully regulate the amount of certain chemicals, such as the algicides, that they add to cooling water to prevent fouling of condensers. Excessive amounts of these chemicals dumped into a fish-raising area might kill the fish. However, experience in Great Britain [11, p. 34] has indicated that this problem can be effectively handled.

Potential Demand for Increased Production of Fish

Population growth projections indicate that food and protein needs will increase substantially in the future.[3] As the previous discussion suggests, production of fish also might be increased amply with the use of aquacultural methods of fish production. However, neither the need for protein nor the large potential production capacity of aquaculture is sufficient to ensure that a viable fish-farming industry will develop. Whether this will occur depends partly upon the effective demand for fish, which is a function of prices, tastes, preferences, market distribution facilities, competition with other foods, and income levels.

[2] This recommendation was contained in a report on the physical and ecological effects of waste heat on Lake Michigan by the Great Lakes Fishery Laboratory [18].

[3] The U.S. Department of Commerce in its Series C and Series D estimates (based on intermediate growth rate assumptions) projects the population of the United States to increase to 280–300 million people by the year 2000 [14, p. 1]. An increase to the 290 million, mid-point in the above range, represents an increase of 41 percent over 1970 population levels. An increase of this size, plus the possibility of exports to currently less developed countries where population growth may be more rapid, could substantially increase the future demand for food and protein.

Per capita consumption of fish in the United States was 14.1 pounds in 1969 [13, p. 576]. This figure is relatively low in comparison with per capita consumption of beef, pork, and poultry, which in that year averaged 111, 65, and 48 pounds, respectively [13]. Per capita fish consumption has remained within the relatively narrow range of 12.9 to 14.1 pounds per person during 1955–1969 [13, p. 576]. The stable per capita consumption figures contrast rather sharply with those for beef and poultry, which have increased strongly in recent years.

The income elasticity of demand for fish in the United States is moderately low. Brandow reports an income elasticity of .42 for fish in the United States [3, p. 17]. Christy and Scott [5, p. 35], in a more recent study, report an income elasticity for fish of .3 for the United States. Compare these two estimates, which average .36, with Brandow's income elasticity estimates of .47, .57, .32, .37, and .49, respectively, for beef, veal, pork, chicken, and turkey [3, p. 17]. Thus, other things being equal, as incomes increase, the quantity of fish consumed will not increase as fast as consumption of beef, veal, and poultry.

Assuming that .36 income elasticity is an appropriate measure, a continuation of the 3 percent per year growth in real income of the 1960's will result in an increase in fish consumption of slightly over 1 percent per year. Population increases should provide additional consumption increases of 1.4 to 1.5 percent per year.

Brandow reports a −.65 price elasticity of demand estimate for fish in the United States [3, p. 17]. One must be cautious about drawing inferences from this figure for an industry where more of the fish would be farm or aquaculturally produced. The demand elasticities for individual types of fish also might differ from the aggregate estimate. But if the Brandow figure is reasonably representative, it suggests that, other things equal, increases in sales of fish would decrease total revenue for the industry.

Marketing has been difficult for fish farmers. This is partly because they lack experience in performing this function, supplies have not been as dependable and uniform as desired, and consumer demand varies substantially from area to area. To some extent, however, these are problems of a new industry and may diminish in importance as producers get larger, gain knowledge of markets, and acquire additional production and marketing research information.

It should be less costly to create demand for fish produced in aquacultural facilities than for "wild" fish. Quality control would be easier. Fish marketed by an experienced aquaculturalist should be of more uniform size than those caught by commercial fishermen. Presumably, since refrigeration facilities might be more readily available, there would be fewer problems with deterioration.[4] Fish producers should be able to guarantee delivery of a certain amount and quality of fish, something that is not feasible when deliveries depend upon what can be caught. Advertising and modern merchandising techniques also become effective for demand expansion when the product is of predictably good quality. Prices for aquaculturally produced fish also are higher, a factor which may encourage efforts to expand sales. For example, farm-produced catfish have sold for .22 to .34 cents per pound more than wild catfish [15, p. 48].

The figures suggest that the potential demand for the increased amount of fish that could be produced in aquacultural facilities is not particularly strong. Fish is not a staple in the U. S. diet; the demand for fish is not growing rapidly; and if fish farmers increase production substantially, industry returns may decline. The nature of the product may be such that the demand for aquaculturally produced fish can be expanded by modern merchandising and marketing techniques. Indeed, it seems evident that if aquaculture is to develop into an industry even roughly comparable to the poultry industry of the South a substantial amount of market development effort will be necessary. If a viable industry develops it will probably consist primarily of larger firms (or large producer cooperatives) which can handle the complex production and merchandising techniques that may be required to raise and market food fish.

The possibility of integrating former fishermen into fish farming has been suggested [2]. For the most part fishermen are considerably older and less well educated than the average male worker in the United States [2, pp. 139–141]. A labor force advanced in age and limited in education

[4] Fish tend to deteriorate quickly after being removed from water. One of the earliest changes is autolysis, during which certain enzymes digest the tissues causing a softening or partial liquification of the tissues and a change in flavor and odor [5, p. 28]. In fish the results of this change are highly disagreeable to the human palate. The matter of perishability assumes some importance since the demand for fish is strongly influenced by the availability of supplies of suitable quality. It also accounts for the fact that in the United States rates of consumption of fresh fish are noticeably higher in cities near producing areas [5, p. 22].

may provide an unsuitable core around which to mobilize a technologically advanced fish-farming industry.

Conclusions

Considering aquaculture as it may develop, several generalizations seem to be reasonable. Different types of production facilities are likely to exist side by side, namely, naturally heated ponds, tanks, or other confinement facilities, and perhaps artificial environments using heated water from thermal generating plants. The character of the industry probably will be shaped importantly by the outcome of research now under way on fish genetics, parasite control, disease control, and other aspects of confinement raising of fish. In addition, if the industry is to make substantial growth, efforts to expand the demand for fish will be necessary.

The use of waste heated water as a supporting medium for a symbiotic food-producing industry may appear to be novel. However, if fish can be raised profitably in connection with power-cooling facilities, this would offset part of the cost of the water-cooling equipment. Thus, as pointed out in the essay, thermal pollution might be reduced without increasing consumer electricity bills. To our increasingly consumer-oriented, ecology-conscious society, these may not be regarded as small benefits.

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[9] Great Lakes Fishery Commission, *Summary of General Environmental Conditions and Trends with Great Lakes,* 1970, June 1970.

[10] Greenfield, J. E., *Economic and Business Dimensions of the Catfish Farming Industry,* Bureau of Commercial Fisheries, U. S. Department of Commerce, Ann Arbor, Jan. 1970.

[11] McNeil, William J., ed., *Marine Aquaculture,* Corvallis, Oregon State University Press, 1970.

[12] Spilhaus, Athelstan F., "Geotechnology, Objectives, Demand, Imagination, Planning," *Technology Week,* Jan. 23, 1967, pp. 69–71.

[13] U. S. Department of Agriculture, *Agricultural Statistics, 1970,* Washington, D. C., 1970.

[14] U. S. Department of Commerce, Bureau of the Census, "Projections of the Population of the United States, by Age and Sex (Interim Revisions): 1970 to 2020," in *Current Population Reports,* Series P-25, No. 448, Washington, D. C., 1970.

[15] U. S. Department of the Interior, Bureau of Commercial Fisheries, *A Program of Research for the Catfish Farming Industry,* Ann Arbor, Sept. 1970.

[16] ———, *Fishery Statistics of the United States, 1950–1969.*

[17] U. S. Department of the Interior, Federal Water Quality Administration, *Feasibility of Alternative Means of Cooling for Thermal Power Plants Near Lake Michigan,* Aug. 1970.

[18] U. S. Department of the Interior, Fish and Wildlife Service, *Physical and Ecological Effects of Waste Heat on Lake Michigan,* Great Lakes Fishery Laboratory, Ann Arbor, Sept. 1970.

Master's Theses

Robert Clark Lewis, *The Marginal Costs of Alternative Levels of Water Quality in the Upper Mississippi River*, University of Minnesota, 1970.

The use of natural waterways for waste disposal and the subsequent adverse effect on the quality of the water is competitive with downstream water uses. This fact is illustrated by the uses of the Mississippi River above and below the Twin Cities metropolitan area. Upstream from the Twin Cities the water is of sufficient quality for recreational and aesthetic uses as well as for potable water supplies. Downstream from the Twin Cities the river actually becomes an open sewer at critical low flows, with the result that recreational and aesthetic activities along with the use of the river for potable water supplies not only are curtailed but are dangerous to human health.

The major objective of the study is to test the hypothesis that a minimum cost management scheme can be found that will maintain the current DO river standard in the study area in a manner that is both physically and economically feasible under existing conditions. This objective is accomplished by presenting a model that combines the predicted waste assimilation capacity of the river with the results of the cost survey and then solving this model for the least-cost management scheme for achieving the current river standard in the study area.

The mathematical formulation of the model was set up in such a way that the least-cost management plan for maintaining the DO river standard could be obtained by solving the system with the linear programming algorithm. This formulation of the problem has four parts: first, the objective function; second, a set of constraints and a set of equalities reflecting the physical capabilities and operation of the sewage treatment plants; third, a set of "inventory" equations which record changes in BOD and DO deficit concentrations from point to point in the river where mixing of different concentrations occurs; and fourth, a set of specified "institutional" constraints on the DO deficit concentration at specified intervals in the river.

Based on solutions obtained, the highest DO river standard that is physically possible in the study area (with the current treatment facilities) is 3.43 mg/1, at an estimated total annual cost of $3,697,056 or an increase in total yearly expenditure of 4.8 percent. This solution implies the acceptance of the hypothesis that a cost-minimizing management plan can be devised that will maintain the current DO river standard in the study area in a manner that is both physically and economically feasible under existing conditions.

Richard Wayne Simunek, *An Evaluation of Age, Liquidity, and Strategy on Intergeneration Farm Transfer Cost*, Washington State University, 1970.

This study evaluated the effects of age, strategy, and farm indebtedness on intergeneration farm transfer cost. The farm transferred was a Palouse wheat farm valued at $594,800 with an average annual income of $22,245. Transference of the farm was examined through use of a simulation model consisting of four components representing the farm operation and transfer processes: (1) income generation, (2) death probability, (3) estate settlement, and (4) transfer strategy.

The simulated operation of the farm was initiated at the operator ages of 45, 55, and 65 to evaluate the effects of increasing age on transfer cost. Liabilities of $150,000 were added to the initial farm unit to evaluate the effect of increased indebtedness on transfer cost.

Three strategies permitting increasingly earlier transfers were evaluated as to their effect on transfer cost. Strategy one permitted no gifts. Strategy two made cash gifts within the annual and lifetime exclusions. Strategy three equated the marginal rates of gift and estate taxation.

Of the three variables examined, farm indebtedness was found to be the most important factor affecting transfer cost. Only a small amount of gifts were made under strategy two due to the unavailability of cash resulting from debt-servicing requirements. Reduced earnings under strategy three and subsequent inability to meet consumption and debt-servicing requirements resulted in a negative estate. This yielded a smaller total transfer size than occurred under strategy one.

Strategies calling for early transfers were found to be more important than age in reducing transfer cost for the farm unit with no initial liabilities. Although the initiation of transfers at an early age reduced transfer cost in comparison to later ages, strategies two and three reduced transfer cost for all three ages in comparison to strategy one.

AMERICAN AGRICULTURAL ECONOMICS ASSOCIATION

REPORTS AND MINUTES

REPORT OF THE PRESIDENT

Few members realize the amount of time that the president, the Executive Board, and other nonpaid officers devote to the Association. Hundreds of hours are given freely by the committee members as well. This has been one of the secrets of our success, even though it involves financial support by the institutions from which officers and committee members are chosen. During the past year the "budget crunch" across the country, as never before, placed constraints on this method of operation. This fact and what I have called the tendency toward fragmentation constituted two highlights of 1970–71. The budget crisis in various institutions across the land precipitated a variety of demands to the Association for committee funding, which has never been Association policy. What in my Presidential Address I termed the search for meaning in our professional as well as our personal lives, in my opinion, has precipitated a scramble for new forms of organization with which agricultural economists can identify. This scramble endangers the outstanding work of the AAEA in that its members are attaching themselves to many structures that have only horizontal significance.

In several newsletters I tried to keep the membership abreast of the affairs of the Association and my own thinking. The reports of the secretary-treasurer, editor, and all the committees follow below. There for all members to read, also, are the minutes of the Executive Board meetings in Detroit and Carbondale, as well as the minutes of the annual business meeting. As will be recognized from these and other matters, the business of the Association is becoming larger as well as more complex.

As can be seen from the report of the secretary-treasurer, the Association did not escape the budget crunch. One of the reasons for this, of course, was the inflation; but a second and more important reason was that the Association became more active in providing services to its members. Heretofore the principal service of the Association has been the printing of the Journal and publishing triennially a directory of its members. During the past year, however, the Board voted to consummate the special work on abstracting and the bibliographical service and to bear the costs of a special committee which has been working on a postwar literature review project. In addition, another committee, whose function has been to put together a uniform brochure on the profession for undergraduate recruitment purposes, has resulted in increased expenses. All of these and other penetrations into the service arena will bring benefits no doubt, but they have also increased our costs.

The matter on which the president and the Board spent a great deal of time during the past year was the bringing to fruition of the American Bibliography of Agricultural Economics. This project turned out to be more involved than any of us had realized when we committed ourselves to it several years back. The Board voted at its summer meeting to underwrite this project for one year, after which further decisions will be made. Subscription to the Bibliography will be $10 per year. But it is the sense of this president that, unless this project is self-sustaining, the general membership is not in the mood to increase dues to pay specifically for this service.

The postwar literature review activity is one that has been under way for some years, and there has been some concern expressed by Association members and Board members regarding the slowness of the forthcoming articles. The object of this activity was originally and still is to publish articles reviewing in depth the literature since World War II. Lee Martin of the University of Minnesota has been in charge of this project and gave the Board the impression at its annual meeting that 1971–72 will see substantial material progress on this endeavor. Let us all hope so.

The president appointed a committee to make recommendations relative to program formulation for the annual meeting. This committee was chaired by Luther Tweeten, and the result of the committee's report was that the Board unanimously agreed to amend the bylaws of the Association so as to constitute itself a program committee to assist the president in program formulation. The method by which this will be done is that the president-elect will bring to the annual meeting a broad outline of his ideas; and the Executive Board will sit with him to review the ideas, giving suggestions, after which the president (who had been president-elect until the annual meeting) will gather all the ideas and come to the winter meeting with a program substantially in order for the next summer. In my opinion this is a very progressive step.

Along the same line an ad hoc committee was appointed to study the matter of AAEA committee structure. Appointed by the president, this committee will include a past president. A particular objective of this is that the committee structure give adequate attention to representativeness in the Association. In this regard, as I pointed out in a newsletter to the Association, an extraordinary effort was made to assure representativeness from various geographical regions as well as interest groups. Also, as regards presidential action, the membership should realize that while there are more than 200 people involved in Association business only the president can coordi-

nate the appointments and coordinate the program under the constitution under which the Association now operates. Harold Breimyer began a system of accounting of appointments by institution over time, etc., and Dale Hathaway kept this up. I passed this updated accounting on to Vernon Ruttan so that there might be a proper historical and institutional perspective of committee membership.

The Executive Board authorized Dale Hathaway and Loys Mather to continue their work so as to get a better employment service for agricultural economists. This continues to be a very serious matter and an item of first priority in view of the changes in our professional labor market. The objective, as recommended by a committee chaired by Loys Mather, is the establishment of a year-round employment service; and the Executive Board authorized the committee to proceed to intensify its study of the matter.

The matter of awards has been a subject with which the Association and the Board have been concerned for some time. The Board authorized an evaluative study of the entire awards program with the view of seeking an improvement in achievements as related to costs, and a report will be made by this committee at the next annual meeting. Chester Baker, current overall awards chairman, will lead in this effort.

Some concern has been expressed that the Association is in need of a full-time executive secretary. This matter was considered fully by the Board and dropped because of the current financial position of the Association. It was thought that we should continue operating in the present manner until our financial position can clearly justify such an action.

A continual matter before the Executive Board has been that of voting full membership to regional associations. This matter was again brought before the Board this year; no action was taken.

A Brochure Committee, appointed in the past, was very active during the year and presented the Board with a facsimile at its annual meeting. The Board moved to authorize the printing of 30,000 copies by any method the committee selects and to sell these copies on a cost basis to the institutions who want them. The facsimile was turned over to John Redman who assumed the responsibility of printing and selling.

One of the most active committees of the Association during the year was the Committee on Education. A very fine report was given to the Board by Chairman James Nielson, and that committee was authorized to conduct an annual survey of information on curriculum changes in agricultural economics and make this information available to all concerned. The Committee on Education was also authorized to initiate and plan a 2½-day workshop to be held in conjunction with the annual meeting in Florida next August. The Committee was authorized to publish the proceedings of this workshop in Journal format, but it was specified that it be edited to 50 pages. The Journal editor will explore the alternatives of publication and the price of extra copies.

The Student Affairs Committee, under the leadership of John Sjo, did its usual outstanding job. The Board authorized this committee and its officers to study the role of the student section and the student affairs awards and to coordinate this study with the overall study of the awards program.

The Industry Committee, under the leadership of Charles Erickson, turned in an outstanding performance and has underway plans and activities which will contribute to the educational needs of the profession.

One of the concerns of the Extension Affairs Committee has been the criteria for the selection of awards. This is summarized in the report of that committee, which can be read as part of its full report.

The Board voted to authorize a serious study of the classification of the fields of interest of agricultural economists the next time the membership directory is published. There is some dissatisfaction with the old classification which has been with us for some years. This will be the duty of a future president, and I am sure that he will appreciate any suggestions.

Many other committees were quite active during the year; to mention a few: the Membership Committee, the Economic Statistics Committee, and the various representatives of the Association with other organizations such as the National Research Council, the National Bureau of Economic Research, etc.

There was a move during the year to get the AAEA involved in a Council of Agricultural Sciences to be composed of professionals of all agricultural societies and to have a representative in Washington to look out for the best interests of "agriculture," whatever that is termed to mean. The Board elected to go slowly in this matter for two reasons, the first being the exemptions we now hold from income tax as a nonprofit and nonlobbying organization. Secondly, the Board thought that the interests of the AAEA might not be the same as those of certain agricultural societies; therefore it elected to maintain a liaison but not to become affiliated at this time with this Council.

As with most presidents, most of the work was a matter of continuing programs and committee activities which had already been set up during past administrations. Let me take this opportunity to thank all who have formally served during my tenure. I thank also those who have written or passed on suggestions to me. I again point out that one of our strengths is the selfless, unremunerative nature of the service that members devote to the Association.

It was an honor and a pleasure to serve you. As Dale Hathaway before me said, however, and I repeat: I'm happy that it's a one-term office!

Respectfully submitted,
JIMMYE S. HILLMAN

RESOLUTION

WHEREAS, the Southern Illinois University at Carbondale has hosted in a most efficient and pleasant way this national conference of the American Agricultural Economics Association, and,

WHEREAS, handling the local arrangements for this Association is a large, intricate and time-consuming task,

NOW, THEREFORE, be it resolved the Association records and transmits its thanks and appreciation to the appropriate officials of the Southern Illinois University for these efforts on our behalf. Particular note is to be taken of the efforts of Walter J. Wills, Albert W. Gustafson, Mrs. Wendell E. Keeper, Mrs. Walter J. Wills and other members of the faculty, staff, students, and wives who worked on the myriad of committees and special projects. Our appreciation is also to be extended to Mayor Neal Eckert and the City of Carbondale.

Be it further resolved that a copy of this Resolution be sent to Chancellor Layer, to each committee chairman, and to others at the Southern Illinois University as appropriate.

Dated this 18th day of August 1971.

REPORT OF THE SECRETARY-TREASURER

The total membership of the American Agricultural Economics Association decreased in nearly every category in 1970 (Table 1). No doubt a large part of the 7 percent decrease was the result of the increase in dues, effective January 1, 1970, and the budgetary constraints experienced by many. During the year the payment of dues was relatively slow, and during the Fall and Winter my office wrote to the 1969 members who had not paid their 1970 dues. The results were excellent and this report reflects only a portion.

About 16½ percent of our regular members and 63⅔ percent of our library subscriptions are foreign. As many of you know, a very large percentage of our library subscriptions are handled by subscription agencies which charge a 10 percent commission.

The financial picture for 1970 turned out to be very favorable with a $25,762.35 gain (Table 2) compared to 1968 and 1969 deficits totaling about $20,000. This favorable picture was the result of the dues increase effective January 1, 1970, and the expenses budgeted for the Bibliography and Handbook that were not made. First, let me caution that this merely recouped the deficits previously made and that we are not on the road to great affluence.

Several items made the financial picture for 1970 appear to be more rosy perhaps than it really was. We collected some back dues (1969) which appeared as 1970 income. We pushed advertising a little more than what can be expected to continue. However, these were minor compared with the tight control (some thought it was too tight) on expenses in order to keep within the budgetary constraints.

Table 1. American Agricultural Economics Association: number of members and subscriptions, 1970 with comparisons

Category		1968	1969	1970
Sustaining members		38	45	39
Regular members	—United States	2,716	2,854	2,667
	Foreign	547	566	534
Junior members	—United States	585	518	494
	Foreign	82	61	84
Corresponding	—United States	—	2	4
	Foreign	187	179	95
Libraries and businesses	—United States	594	645	596
	Foreign	1,024	1,090	1,031
Exchange		3	3	3
Total members and subscribers		5,776	5,963	5,547

Unpaid family labor as well as professional time were used to do mass mailings because of the budgetary limitations. The printing and duplicating were done by Kentucky for only the cost of paper. The anticipated expenditure of $10,000 for the Bibliography resulted in only $1,271 and the $1,000 allocated for the Handbook-Directory was not spent.

In starting my duties as Secretary-Treasurer, I found that I had two large Journal printing bills (about $30,000) to be paid and, with the cost of printing new forms, stocking supplies, etc., I found it necessary to either sell some stock in May (the low month) or to borrow operating money. By choosing to borrow and paying $635.73 in interest, the Association gained approximately $4,200 in the value of that stock. Thus the operating statement will not always tell the whole story and could even give the wrong story.

It is difficult to sound an alarm when we had a surplus for 1970. However, the surplus about offset the total of the previous deficits. The Handbook-Directory and the American Bibliography will cause a deficit for 1971 in spite of the good membership gain normally expected for the Handbook-Directory year. If we continue the activities undertaken and the rate of inflation continues, we shall continue probably to have deficits. In my opinion the Association must find ways to generate new income to finance the already committed programs or simply decide to cut out some of the programs. Dues can be raised again, which at this time appears to be ill-advised. We might learn something about price elasticity. Or a page charge can be initiated based somewhat upon the cost of composition.

It is assumed that publication of the Journal has the highest priority among our activities; by far the biggest expense is printing. Our printer has informed us that we can expect between 20 and 25 percent increase in printing effective January 1, 1972. As you know, we had a 4 percent automatic increase in our

Table 2. American Agricultural Economics Association: 1970 operating statement, with comparisons, and 1971 budget

Item	1969 Actual	1970 Budget	1970 Actual	1971 Budget
Income				
Dues and subscriptions:				
Regular members	$50,179.84	$ 80,000.00	$ 55,336.45	$ 85,000.00
Junior members	—	—	3,152.28	—
Subscriptions	—	—	38,970.15	—
Corresponding members	1,572.00	500.00	1,474.36	—
Sustaining members	4,500.00	4,000.00	3,900.00	4,000.00
American Bibliography of Agricultural Economics	—	—	114.00	10,000.00
Dividends and interest	6,858.56	6,000.00	7,297.65	6,500.00
Journal sales	4,785.84	8,000.00	3,410.76	8,000.00
Reprints	4,314.40	4,100.00	4,824.14	4,500.00
Advertisements	971.00	1,000.00	1,778.50	1,500.00
Student activities	—	—	207.15	—
Annual meetings	1,073.95	1,200.00	865.98	1,000.00
Miscellaneous	437.03	700.00	2,443.03[c]	700.00
Total	$74,692.62	$105,500.00	$123,774.45	$121,200.00
Expenses				
Journal printing	$53,730.96[a]	$ 50,000.00	$ 53,097.53	$ 55,000.00
Editorial support	7,033.74[b]	7,000.00	7,000.00	15,000.00
Editor's postage	600.00	600.00	600.00	1,100.00
Printing and reprints	3,222.79	3,500.00	3,572.15	3,800.00
Addresses and labels	—	—	120.29	—
Purchase journals	457.00	1,000.00	942.66	1,500.00
Postage and telephone	1,991.73	1,600.00	659.26	2,000.00
Office supplies and printing	1,131.08	1,000.00	1,686.25	1,200.00
Annual meeting	1,530.43	2,625.00	2,041.46	2,600.00
Awards	3,050.16	3,100.00	3,600.00	3,100.00
Committees	2,328.14	2,000.00	2,326.63	2,000.00
Bonds	135.00	140.00	131.00	140.00
Student activities	920.40	1,000.00	180.46	1,000.00
Secretary-Treasurer assistance	7,915.11	8,000.00	8,058.06	9,000.00
Secretary-Treasurer honorarium	3,000.00	3,000.00	3,000.00	3,000.00
Audit	—	250.00	225.00	—
American Bibliography of Agricultural Economics	—	10,000.00	1,271.00	14,000.00
IAEA grant	—	5,000.00	5,000.00	—
Handbook	—	1,000.00	—	22,000.00
Move, Secretary-Treasurer office	—	300.00	355.33	—
Interest expense	—	—	635.73	—
Exchange fees	—	—	273.77	—
Miscellaneous	58.43	500.00	3,235.52[d]	500.00
Total	$ 87,104.97	$101,615.00	$ 98,012.10	$ 136,940.00
Balance	$−12,412.35	$ 3,885.00	$ 25,762.35	$−15,740.00

[a] Includes $22,500 estimated for December 1969 issue.
[b] Includes $33.74 for previous editor.
[c] Includes $2,000 for loan repayment by University of Missouri.
[d] Includes $2,000 loan and $832.25 refunds made.

contract which became effective on January 1, 1971. Since some $15,000 to $19,000 will be added to our printing expense, I asked our printer to do a detailed analysis of the cost factors and make suggestions on cost reduction for our consideration. Frankly, I have very little hope for much savings because composition is the expensive item and is directly related to the amount of mathematical and statistical material involved.

Prior to 1968, the policy was firm in that no travel expenses would be paid for committee meetings. Presumably, if the committees are productive, professional recognition should compensate the individual and his institution for the input. While President Hillman has done an excellent job in holding down committee travel expenses, it would be easier for succeeding presidents and Boards to handle this rapidly increasing pressure if the policy of no travel expense were reestablished.

Obviously the whole question hinges on what the members are willing to pay for.

The Balance Sheet for the Association at the close of the fiscal year improved because of the favorable income-expense ratio for the year (Table 3).

Table 3. American Agricultural Economics Association: balance sheet, December 31, 1970

Assets		
Cash, Bank	$32,048.68	
Cash, Agency account, University of Kentucky	2,806.54	
Cash, Broker	897.76	
		$35,752.98
Investments, at cost		
Corporate bonds (approximate market value, $16,231.25)	$22,936.91	
Stocks (approximate market value, $154,465.00)	64,627.98	87,564.89
Total assets		$123,317.87
Liabilities		
Notes payable	$ 7,784.43	
Prepaid membership dues	29,080.50	
Accounts payable	22,751.83	
		$ 59,616.76
Net worth		63,701.11
Total liabilities and net worth		$123,317.87

Since 1970 was my first year as Secretary-Treasurer, I want to express my appreciation for the privilege of serving. I can have a greater appreciation of what a fine job my predecessor, Dr. C. D. Kearl, did. There was much learning to do, and I assure you there is much more to this office than perhaps most members realize.

Respectfully submitted,
JOHN C. REDMAN

AUDIT REPORT

Dear Dr. Hillman:

As requested in your July 10, 1970, letter, Dr. James C. Criswell and I conducted the annual audit of the financial affairs of AAEA. We have examined the financial records of the AAEA as of December 31, 1970.

As part of our audit, we examined the income and expense accounts, inspected the checking account, confirmed the reported inventory of securities, and checked the financial balance sheet. Other aspects of the financial affairs of the organization were reviewed, including the Secretary-Treasurer and Investment Committee reports to be presented at the August business meeting.

We found the financial records to be correct and, in our opinion, accurately reflect the financial position of the American Agricultural Economics Association as of December 31, 1970.

Respectfully submitted,
FRED E. JUSTUS, JR.

REPORT OF THE INVESTMENT COMMITTEE

The Investment Committee had very little activity during 1970. The stocks and bonds purchased by the Association over a period of years at a total cost of $87,564.89 were worth about $170,697.00 at the end of the year (Table 1). During the year they yielded the Association $7,297.65 in income, which was $439.09 more than yielded in 1969. However, the sale of rights for Standard Oil of New Jersey and American Telephone and Telegraph produced $159.60 of this increase.

Table 1. American Agricultural Economics Association: summary of investments, December 31, 1970

Item	Income January 1–December 31, 1970	Value: Cost	Value: Market
Stocks			
On hand, January 1, 1970		$64,627.98	$143,552.50
Change during year			
On hand, December 31, 1970		64,627.98	154,465.75
Dividends and Income Received	$6,185.15[a]		
Corporation bonds			
On hand, January 1, 1970		22,936.91	14,960.00
Change during year			
On hand, December 31, 1970		22,936.91	16,231.25
Interest Received	1,112.50		

[a] Including $159.60 for rights sold.

The market declined generally in 1969 and reached a low in May 1970, with the total value of our stocks falling to $111,296.25 on May 26. All of our stocks except three (Chase Manhattan, Continental Can, and Owens Illinois) were worth more at the end of the year than at the beginning (Table 2). The total value at the end of the year was $40,168.25 more than on May 26. One of the stocks (Continental Can) split three for two during the year. The stocks yielded approximately 4.3 percent based on the value at the beginning of 1970.

The corporate bonds increased in value over 1969, closing by $1,271.25 as the value reached $16,231.25 by the end of 1970 (Table 3). The investments in bonds have not proven to be a profitable alternative. The loss in value of the bonds over time has nullified much of the income.

Considering the nature and size of activities the Association has underway, the size of investments is not large. They help produce income to defray current operating expenses. More important, however, they provide a financial base to stabilize the business activities and provide a credit rating so the Association can borrow money for short periods of time and enjoy the convenience of conducting business activities without prepayment.

Prepared by JOHN C. REDMAN
for the committee

Table 2. American Agricultural Economics Association: stocks, December 31, 1970

Company*	Inventory: Number of shares	Inventory: Original cost	Dividends: January 1–December 31, 1970	Market value: December 31, 1969	Market value: December 31, 1970
Am. Tel. & Tel. (A+)	288	$11,421.11	$ 936.00	$ 14,004.00	$ 14,076.00
Borden Co. (A+)	228	2,162.41	273.60	5,244.00	6,156.00
Chase Manhattan Bank (A+)	93	1,115.09	167.40	4,836.00	4,766.25
Clark Equipment (A−)	600	2,200.67	840.00	19,800.00	22,050.00
Com. Edison Co. (A+)	232	7,467.14	510.40	8,700.00	8,903.00
Continental Can (A)[a]	225	4,315.38	345.00	10,818.75	8,746.875
General Electric (A+)	150	1,920.57	390.00	11,625.00	14,081.25
Jewel Co. (A)	100	3,875.94	150.00	4,400.00	5,275.00
Owens-Illinois (A)	140	2,925.35	189.00	8,680.00	7,980.00
Sears Roebuck (A+)	304	1,845.38	410.40	20,672.00	23,180.00
Std Oil, Indiana (A)	400	7,356.68	920.00	19,200.00	21,050.00
Std Oil, New Jersey (A+)	153	10,325.36	573.75	9,447.75	11,226.375
Texaco (A+)	200	7,696.90	320.00	6,125.00	6,975.00
Rights[b]			159.60		
		$64,627.98	$6,185.15	$143,552.50	$154,465.75

* Standard and Poor ratings shown in parenthesis.
[a] Split 3 for 2, adding 75 shares.
[b] Rights for Standard Oil of New Jersey $41.52 and American Tel. & Tel. $118.08.

Table 3. American Agricultural Economics Association: corporate bonds, December 31, 1971

	December 31, 1970: Inventory (at cost)	December 31, 1970: Market value	Interest: January 1–December 31, 1970	Maturity: Value	Maturity: Date
Am. Tel. & Tel.	$ 5,046.91	$ 3,675.00	$ 256.26	$ 5,000.00	4/1/01
Iowa Ill. Gas & Elec.	5,200.00	3,456.25	243.76	5,000.00	5/1/91
Pacific Tel. & Tel.	10,650.00	7,600.00	512.48	10,000.00	2/1/93
Witco Chem. Co.	2,040.00	1,500.00	100.00	2,000.00	6/1/80
	$22,936.91	$16,231.25	$1,112.50	$22,000.00	

REPORT OF THE EDITOR

Manuscript receipts through the year ending June 30 were at the same level as in the previous year—249 vs. 250. During the approximate counterpart publication year (the November 1970 through August 1971 issues) 101 items were published. The overall acceptance rate remained at the same level as last year—38 percent.

Submission of manuscripts was especially heavy during May and June. Consequently the incoming editors entered their regime with a substantial inventory already at hand. Those with penchant for statistical uniformities might watch for a step-function associated with change of editorial regimes. In 1969 I reported a 30 percent increase in manuscript submissions over the previous 3-year average reported by Earl Swanson, but it proved to be a new plateau rather than a trend. If early indications hold, the incoming Polopolus-Langham regime also may be facing new magnitudes, either in trend or plateau. We have given them the best we could as a blessing but it may be they will need more divine help.

A question that may interest authors and readers is whether the introduction of the *Research Notes* section in August 1969 had the effect of reducing other components, especially articles. Since research notes usually are derived from manuscripts originally proposed for articles, a reasonable presumption is that their entry would be at the cost of articles. The question can be answered by comparing the content of the 10 issues preceding August 1969 with that of the 10 following issues (excluding proceedings issues and winter meeting items in May issues):

	Articles	Research Notes	Communications	All items
Ten issues preceding 8/69	115	—	101	216
Ten issues 8/69–11/71	104	48	121	273

The offset to an average of almost five research notes per issue has been approximately one article. Accordingly, our expectation on *Research Notes* is quite well affirmed—that it would be a means of utilizing materials not warranting a full article and portions of manuscripts the entirety of which would not have been publishable as an article. *Communications* meanwhile have gained. (A word of caution to anyone who discovers that Volumes 51 through 53 each contains 41 refereed articles: You may as well be surprised too, and let it go at that; the consistency has no rational explanation.)

One encounters the comment, occasionally stated less than impassively, that the JOURNAL carries too much of this or not enough of that, and sometimes it is with the implication of editorial whimsy or bias. *AJAE*'s editor does have some control over its composition but precious little. I candidly have been biased in favor of material submitted by extension economists, industry economists, and graduate students and have made extra efforts to encourage and utilize materials from these sources. The Association's objective "to further the development of systematic knowledge of agricultural economics for the purpose of improving agriculture and agriculture's contribution to the general economy" has served as a guideline as to relevant and significant material. Under it we have declined the proposition that *AJAE* exists to publish whatever agricultural economists write. Interests of agricultural economists are increasingly diverse, and new publication outlets have entered the scene; accordingly we have declined papers that seemed to have no particular relation to the Association's objective. Beyond these very minor constraints the JOURNAL's subject matter profile is determined by the array of interests of those who offer material to it. The editor is not in the rationing business by category or in total; his primary job is to conduct the process of judging worthiness.

Allen Paul has run his own show as Book Review Editor, and I believe he has done an excellent job. There has been surprisingly little conjoining of issues between book reviews and other contents of the JOURNAL. The Kelso-Martin and Glenn Johnson communications in May 1971 and November 1971 are the only instances that come to mind. My only involvement in book reviews has been to support the policy of not accepting self-initiated reviews and helping to resist those who were overly keen about proffering their reviews or their books for review.

Acceptance ratios seem to be a popular statistic. My predecessors and I have reported those for this journal as being in the vicinity of 40 percent. In contrast, *AER*'s ratios in recent years are reported at 14 and 18 percent. Both journals count all items submitted and all items published. *AJAE*'s acceptance rate on communications is high, which gives an upward bias to our ratios if one is thinking in terms of article manuscripts. Nevertheless, our output level is comparatively favorable. *AJAE* has available to it only one-fourth to one-third of the number of manuscripts submitted to *AER*. Yet in the two years 1969–1970 we had 82 refered articles as against *AER*'s 99. In 1969–1970, *AER* carried 135 communications, notes, comments and replies; our comparable total was 125. For whatever reasons and at whatever cost, *AJAE* does maintain a nigh output ratio.

An intensive review and revision process undoubtedly has some effect on our productivity. Publication without substantial revision has seldom occurred. Second and even third revisions are not unusual. Costs involved here, in addition to time and energies of authors and their supporting institutions, are substantial though rather broadly distributed. Expertise, time, and energy of the Editorial Council and of the far more numerous ad hoc reviewers are inputs that if measurable would surely reach astonishing magnitudes. These individuals, together with stalwarts nearer at hand—Hal Carter, Gerry Dean, Miriam Revzan, Allen Paul, and my colleagues at Davis and Berkeley—were the resources that brought printed-page vitality to some of the important scholarship in agricultural economics. For the conscientiousness and good will of all of them I shall always be grateful.

Many seem to be quite aware that attempting to be the JOURNAL's editor has its moments of anguish. But there have been satisfying and affirmative transactions as well. With a bit of self-discipline it should be the latter I shall remember.

VARDEN FULLER

REPORT OF THE SUSTAINING MEMBERSHIP COMMITTEE

In 1970 there were 40 businesses that supported AAEA activities with their sustaining memberships. As of August 1, 1971, 29 of these had paid their membership dues for 1971. Since some corporations have fiscal years commencing in June or July it is common for payments to be received during the last part of the AAEA fiscal and membership year. There is no indication that any of the 11 "unpaid" businesses will drop their membership.

During the year letters have been sent to about 30 business representatives requesting that they consider joining and supporting the Association with their sustaining membership. These letters brought forth only one new sustaining member. This and other experience would indicate that new sustaining memberships are obtained through person-to-person contact. The responses to this year's contact letter generally reflected a slow economic situation and an unwillingness of businesses to make this kind of a commitment in a "slow" year. Letters read: "Due to our present austerity program, we have no funds available for such a membership"; "We are not in a position to become a sustaining member"; "Our budget is exhausted"; etc.

As the economy picks up, a "selected" committee

headed by an "industrial" economist might well increase the number of sustaining members. The suggestion of an "industrial" economist and a "selected" committee expresses a feeling that this committee should be closely in tune with the attitudes and policies of businesses if it is to succeed in expanding the sustaining membership of AAEA.

C. D. KEARL, *Chairman*

REPORT OF THE AWARDS COMMITTEE

This report relates specifically to the AAEA awards for extension, teaching, and research (theses and published). It excludes the awards provided for undergraduate students and for authors of the outstanding article in *AJAE.*

Announcement brochures were mailed to academic departments in the United States and Canada and to research units of the U. S. Department of Agriculture. The entry conditions and instructions contained in the brochure also were published in the JOURNAL. An award for Distinguished Extension Publication was provided for the first time. Also new was a division of undergraduate teaching awards: one for a teacher with less than 10 years of experience and one for a teacher with 10 or more years of experience. The extension awards were $250 each. A total of $250 was divided equally between recipients of the two undergraduate teaching awards.

The Awards Committee strongly recommends an increase of cash award for Distinguished Undergraduate Teaching to $250 for each category.

Judging committees reported strong interest in all the contests. Problems remain in (1) application of defensible criteria in comparing entries in each of the contest categories and (2) managing the logistical problems. The latter problems were especially vexing in the case of doctoral theses and resulted in difficulties in meeting deadlines in naming winners. This committee also commented on the poor physical condition of theses when received. Finally, a considerable variability was found among judges in rankings given to final-round theses in the doctoral category.

These and other items will be considered in a review of the AAEA Awards Program, to be accomplished in 1970–71. The Awards Committee, consisting of the general chairman and the chairman of each of the five judging committees, is charged with the responsibility of bringing to the AAEA Board recommendations for the Program: continuation or abandonment and, if the former, changes to improve the contribution the Program makes to the objectives of AAEA.

It is suggested that, in the execution of the current Awards Program, criteria used to judge entries could be made available to all the organizations who receive the Announcements brochure. Consideration also might be given to publishing the criteria in the JOURNAL.

C. B. BAKER, *General Chairman*

AWARD WINNERS

Distinguished Extension Publication

WILLIAM M. CARROLL, Pennsylvania State University

Distinguished Extension Program

J. H. ARMSTRONG AND H. V. COURTENAY, Purdue University

Distinguished Undergraduate Teacher

JOHN W. GOODWIN, Oklahoma State University (less than 10 years)

LAWRENCE B. DARRAH, Cornell University (10 years or more)

Master's Thesis

ROBERT CLARK LEWIS, "The Marginal Cost of Alternative Levels of Water Quality in the Upper Mississippi River," University of Minnesota.

JAMES ARNOLD LIEFER, "Attitude Toward Land Ownership and Usage in North Central New Mexico State University.

RICHARD WAYNE SIMUNEK, "An Evaluation of Age, Liquidity and Strategy on Intergeneration Farm Transfer Cost," Washington State University.

Doctoral Thesis

MICHAEL DEAN BOEHLJE, "Strategies for the Creation and Transfer of the Farm Firm Estate," Purdue University.

FREDERICK JAMES PROCHASKA, "Opportunity Cost of Time and Other Socio-Economic Effects on Away-From-Home Food Consumption," North Carolina States University.

SOLOMON BEKURE, "An Economic Analysis of the Intertemporal Allocation of Gound Water in the Central Ogallala Formation," Oklahoma State University.

Published Research

YUJIRO HAYAMI AND V. W. RUTTAN, "Factor Prices and Technical Change in Agricultural Development: The United States and Japan, 1880–1960," *The Journal of Political Economy,* 78:1115–1141, September/October 1970.

C. RICHARD SHUMWAY, GORDON A. KING, HAROLD O. CARTER, AND GERALD W. DEAN, *Regional Resource Use for Agricultural Production in California, 1961–65 and 1980,* Giannini Foundation Monograph 25, University of California, September 1970.

G. EDWARD SCHUH, *The Agricultural Development of Brazil,* New York, Praeger Publishers, 1970.

Outstanding Article in the JOURNAL

ANDREW SCHMITZ AND DAVID SECKLER, "Mechanized Agriculture and Social Welfare: The Tomato Harvester," *American Journal of Agricultural Economics,* 52:569–577, November 1970.

REPORT OF THE STUDENT AFFAIRS COMMITTEE

Presently there are 42 charter chapters of the Student Section of the American Agricultural Economics Association. Four chapters were rechartered and five new charters were issued. No charters expired without renewal.

Regional meetings were organized at Texas Tech University and at North Dakota State University this last year.

The Student Section national officers elected for 1971–72 are:

President: A. J. Burns, Louisiana State University
Vice-President: Mike Peacock, Texas Tech University
Secretary-Treasurer: Randy Martin, University of Illinois
Editor: Eddie Miller, Oklahoma State University
Board members: Rich Baker, University of Maryland; Steve Mathis, Oklahoma State University; Don Villwock, Purdue University; Daryl Gustin, New Mexico State University; J. P. Mansfield, Montana State University; Stella Mumme, Texas Tech University; Buster Polling, New Mexico State University.

The 1971 contest winners were:

Debate Contest:

First—Mark Allen and Tom Johnson, University of Illinois. Donald Smith, coach.
Second—Elerth Arntson and Paul Backstrom, North Dakota State University. E. James Ubbelohde, coach.
Honorable Mention—John Neal and Beck Gipson, Texas Tech University. Rex P. Kennedy and James W. Graves, coach.
—Robert Craig and Richard Posthumus, Michigan State University. Larry Conner, coach.

Essay Contest:

First—Gary A. Gilbertson, University of Wisconsin
Second—J. Mickey Burkett, New Mexico State University
Third—S. John B. Stackhouse, University of Guelph
Fourth Place Honorable Mention—Roger Rollings, Purdue University
Fifth Place Honorable Mention—David N. Hall, Clemson University

Speech Contest:

First—David McCoy, Ohio State University
Second—Eddie Miller, Oklahoma State University
Third—Donald Villwock, Purdue University
Fourth Place Honorable Mention—Richard Baker, University of Maryland
Fifth Place Honorable Mention—Billy Davis, University of Georgia

Financial Report

	1969	1970	Estimated request 1971	Estimated request 1972
Cash awards	$600.00	$600.00	$600.00	$600.00
Judges' honorariums	200.00	200.00	300.00	300.00
Newsletters and pictures	0	100.00	150.00	150.00
Plaques, keys, engraving	107.08	70.00	70.00	70.00
Printing and miscellaneous	24.27	20.00	20.00	20.00
	$931.35	$990.00	$1,140.00	$1,140.00
Sale of shingles	—	45.75	24.50	25.00
Charter fees	—	135.00	45.00	20.00
SS-AAEA balance forward	—	61.40	172.68	—

JOHN SJO, *Chairman*

REPORT OF THE EDITORIAL ADVISORY BOARD OF THE AMERICAN BIBLIOGRAPHY OF AGRICULTURAL ECONOMICS

The first issue of the bibliography is in the hands of the University of Kentucky Press and should be distributed in late August. The second and third issues will be combined. It is estimated that these issues will be published in late September. The fourth and fifth issues will also be combined and should be published in October. The sixth issue will then be published in December.

Word has been received via Larry Witt that the Agency for International Development will be able to finance the distribution of the bibliography to approximately 900 foreign libraries.

The bid from the University of Kentucky Press, which was accepted, was somewhat below the original estimates carried in the budget for last fiscal year. The estimated cost for the four publications this year is approximately $4,000.

A mailing list was prepared consisting of two parts:

(1) Domestic and foreign libraries (1600 copies).

(2) Departments of agricultural economics and governmental agencies in the United States and Canada (350 copies). Allocations to each department were based on the number of people listed in the *Professional Workers in State Agricultural Experiment Stations and Other Cooperating State Institutions*, January 1971 edition. Land-grant colleges known as "1890" colleges were included in the mailing list.

The American Agricultural Economics Documentation Center is now on a current day-to-day basis, with publications received that day being forwarded immediately to the appropriate member of the Indexing Committee. The Committee members are returning documents promptly and there is no delay except for journals with many articles to be indexed, which of course takes longer to review and index.

It is hoped that the letter and copy of the indexing guide that was sent to all cooperators will bring a large response. Many states are not sending anything in or are submitting only bibliographic forms. It is necessary that a copy of the publication be sent to the Center. While some states may have smaller pro-

grams and budgets than others, it would be well to insure that their publications are sent to the Center. Some cooperators seem to have been saving documents for long periods of time and sending them all in one package; the citations would be much more current if the reports were sent to the Center as soon as available.

Mrs. Alexander of NAL has negotiated a microfilm contract with a private firm. The procedure is to send documents to be microfilmed when there is a large enough volume, 1,000 at the least. The film will then be available at the Tri-Agency Reading Room, 500 12th St., S.W., Washington, D.C., 20250, and possibly available to others at cost.

After copies of Volume 1, Number 1, have been received and reviewed, all comments, suggestions, and criticisms will be welcomed.

Recommendations

The committee recommends for your consideration three alternative means of financing the bibliography:

(1) A subscription rate of $10 per year for domestic and foreign libraries with the same distribution pattern as that used for the 1971 issues, with governmental agencies and departments of agricultural economics receiving free copies.

(2) Alternative (1) above plus an individual subscription rate of $3 per year.

(3) Subscription rates for domestic and foreign libraries at $10 per year and individual subscription rates also at $10 per year.

Note: It was noted that it would be difficult to effectively discriminate who would qualify for the $3 rate and $10 rate, so alternative (3) was chosen by the Board of Directors of the American Agricultural Economics Association.

LEE M. DAY, *Chairman*

REPORT OF THE PROFESSIONAL ACTIVITIES COMMITTEE

Need for a research committee. Since the Association has committees to foster improvement and professional performance in the areas of industry, extension, international programs, and teaching, the question was raised regarding the need for a parallel committee in the area of research.

The Professional Activities Committee agreed that there was no question regarding the importance of research and the need for improving research performance. However, many individuals and groups in the Association are giving thought to research resource allocation and the organization of research. With agricultural economics research now covering as broad an area as it does, the Professional Activities Committee questions the usefulness of a single AAEA committee on research.

Education in economics for noneconomists. The Professional Activities Committee has recommended that the Extension Committee give major attention to the development of social science expertise for professional agriculturalists in general, most particularly in relationship to rural development, and that the Education Committee consider methods for improving economic education for nonagricultural economics majors.

Exchange of professional people. There is strong concurrence among members of the Committee that we need more exchange of professional people among government, business, and the universities—for periods of six to twelve months.

Members of the Professional Activities Committee, based on their discussion, have improved the possibilities for exchange between government and the universities. The Industry Committee, as well as the Professional Activities Committee, has discussed the improvement of exchange between universities and business. A number of problems impede improvement of the exchange. The Committee will continue to discuss and seek ways of achieving more effective and increased exchange.

The awards program. The Committee took note of the discussion of the awards program presented by Emery Castle, chairman of the Awards Committee for 1970. Castle expressed the belief that the awards program is a liability rather than an asset to the profession. He also pointed out the high cost in terms of time, about 1.6 man-years, devoted to the judging process. Castle pointed out that it is reasonable to suppose that no more than one-half of the total time involved is represented by the judging process. The time required to judge the publications and theses in the various departments and the preparation of the materials for the extension and teaching awards would add at least another 1.5 man-years. Thus, he concluded that the total inputs would exceed three professional man-years.

The Committee also expressed concern for the inexactness of the selection process and the need for continued improvement in the awards program.

It is recommended that the Board request the Awards Committee to make a special study of the program with emphasis on restructuring to improve it significantly or drop it entirely. Questions that may be considered by the Awards Committee in a study are: What should the awards program achieve? Is it worth the cost?

Supply and demand of agricultural economists. The supply and demand relationship for Ph.D.'s is under considerable discussion. In certain of the physical sciences recent recipients of Ph.D.'s are having difficulties in finding employment in their fields.

In the April 9, 1971, issue of *Science,* Allan M. Cartter, in an article entitled "Scientific Man-Power for 1970–1985," suggests that during the decades of the seventies and eighties there will be a serious oversupply of Ph.D.'s, with severe unemployment or underemployment if present trends continue.

Varden Fuller in a Communication in the August issue of the JOURNAL suggests that agricultural econ-

omists are facing labor market disequilibrium of significant if not tragic magnitudes.

The Professional Activities Committee recommends to the Board the formation of a Select Committee to explore demand and supply relationships. It is possible that agricultural economists may not face the same supply-demand relationships as for science manpower in general. In investigating the supply and demand trends for agricultural economists the Select Committee should also look to areas of potential demand expansion for those with graduate training in agricultural economics and recommend action the Association might take to expand demand.

The nature of the Association. The Committee for some time has been concerned with the nature of the Association. There is considerable evidence that the original focus is being lost and that diversity is developing among its members. This feeling was the basis for a recommendation to the Board that the name of the Association be changed to include the word "Applied." An informal vote is being taken on this idea and the results will be received by the Board at its August meeting.

The Committee recommends to the Board that the Association recognize this diversity and capitalize on it as a broad policy position. Specific implications of such a policy position would be development of closer working relationships with regional associations and encouragement of a regional association in the North Central states. In addition, the Association would be sensitive to coalitions of interest in old and newly developing areas such as commercial agriculture, natural resource economics, community development economics, forestry economics, etc. The Association should encourage coalitions of interested people to submit ideas and topics for programs and activities. An example is the program planned by and for forestry economists at this session.

Such a posture would put AAEA in a position similar to the American Economic Association, which encourages the formation of interested groups by providing program opportunities for the groups once they are organized. In essence, the American Agricultural Economics Association would become a "holding company" for the richness and diversity of the interests of its members.

The financial "plight" of the Association and the possibility of a forthcoming increase in publication costs. The Committee recommends to the Board that it study seriously the initiation of a page charge for JOURNAL publications as an alternative to increasing dues.

An executive secretary for the Association. The Committee noted that the subject of an executive secretary for the Association is being discussed. The Committee recommends that the Board study the feasibility of employing a full-time executive secretary.

This person might assume the responsibilities of the current secretary-treasurer and certain details now handled by the editor of the JOURNAL and essentially function as an executive assistant to the president. Also he could be responsible for lining up annual meeting sites and arranging for the facilities, handle the correspondence relating to preregistration and the registration process, and thereby eliminate much of the burden now assumed by host departments.

The assumption of a number of the duties listed above would mean a transfer of budget allocations for those functions to the executive secretary. Should a page charge make the JOURNAL relatively self-supporting, it might be possible to finance the office of the executive secretary without an increase in dues.

An environmental directory for agricultural science is being developed cooperatively by a large number of scientific societies. The societies participated in the development of an index of topics and are nominating members for listing in the directory, which will be distributed to the various media people in the United States.

The Professional Activities Committee was assigned the task of representing the Association in this effort and carrying out the process of obtaining permission of over 65 agricultural economists to be listed in the directory.

R. J. HILDRETH, *Chairman*

REPORT OF VISITING LECTURER COMMITTEE

The program is limited to those universities offering an undergraduate or master's degree, but not a Ph.D. degree. Association funds are not available for the program, and the schools have few funds available to support the program. Attempts are made to match the desire for a particular individual to give a lecture and the availability of that person to travel to the college or university.

A total of 14 institutions indicated a desire for visiting lecturers. When requests for specific individuals were made, the Committee contacted the individuals. According to our records, the following colleges and universities were provided with lecturers:

Colleges and Universities	*Lecturers*
University of Maine	Raleigh Barlowe, Michigan State University
	Allen Kneese, Resources for the Future
Western Illinois University	Dennis B. Sharpe, Federal Reserve Bank of Chicago
Middle Tennessee University	W. E. Hamilton, American Farm Bureau Federation
Southern Illinois University	Luther Tweeten, Oklahoma State University
North Dakota State University	Don Paarlberg, U. S. Department of Agriculture
North Carolina Agri-	Harry C. Trelogan, U. S. De-

cultural and Technical State University	partment of Agriculture · Don Paarlberg, U. S. Department of Agriculture
	Harold Breimyer, University of Missouri
University of Vermont	Kenneth Krause, U. S. Department of Agriculture

Assuming that the Board wishes to continue the program, the Committee requests the Board and members of the Association to contact eligible colleges and universities to make requests for visiting lecturers under the auspices of the program. The Committee will recontact the institutions requesting lecturers last year and set in motion the processes of the program for next year, but would be very happy to receive additional requests.

The Association owes a deep debt of gratitude to those lecturers who went to considerable personal difficulty to give lectures.

R. J. HILDRETH, *Chairman*

REPORT OF THE COMMITTEE ON EDUCATION IN AGRICULTURAL ECONOMICS

The Education Committee held a two-day meeting in Chicago in June. The meeting was preceded and followed by subcommittee as well as individual committee member work. From these activities grew the following Committee recommendations and suggestions:

Roles, supply, and demand for agricultural economists. The Committee recommends that AAEA establish a new committee to give concentrated study to the roles, supply of, and demand for agricultural economists. This committee, after gathering and studying the evidence, would be expected to make recommendations on actions that may be necessary to bring supply and demand into balance. Such a committee should operate on a continuous rather than a once-over basis. John Helmberger of the Education Committee has gathered considerable data on this subject and plans to do further work on it. However, the Committee believes the subject is far too important to be handled as supplementary work within the Association's existing committee structure.

Goals and guidelines for agricultural economics curricula. While it will be an extremely difficult task, the Committee considers it important that the Association develop a statement of curricular guidelines for education in agricultural economics. Further, the Committee accepts this task as part of its mission. Lester Manderscheid has agreed to accept suggestions from other members of the Committee and to draft a statement on behalf of the Committee by the summer of 1972. The statement will include an outline of educational goals in agricultural economics and will suggest how the curricular guidelines can be expected to lead to attainment of the goals. Some knowledge regarding the current and anticipated market for agricultural economists will be needed to complete the statement.

Annual survey of curriculum changes. Subject to the approval of the Board, the Committee proposes to conduct an annual survey to obtain information on curricular changes in agricultural economics. The information would be made available to institutions and individuals who were interested in it and would be helpful in planning workshops.

Educational notes. The Committee recommends that *AJAE* add a section entitled "Education Notes" in regular issues. The section would be parallel to the present section on research notes and would carry items related to both resident instruction and extension education.

In-service training programs for teachers. The Committee urges the Association to encourage and support in-service training activities for agricultural economists. Such education is needed by all members of the profession but appears to be most lacking for those engaged in teaching. The workshop proposed by the Committee would be a contribution to the continuing education of teachers.

Workshop. In its 1970 report the Education Committee recommended that the Association sponsor an annual summer workshop on education. A tentative plan for a workshop to be held in the summer of 1971 was developed and presented to the Board at its meeting in December 1970. The Board appeared to generally favor the idea of a summer workshop but felt that finances and time prohibited the possibility of organizing a workshop for the summer of 1971. The Board instructed the Committee to develop a more specific proposal for a workshop for the summer of 1972. The Committee has done so with the help of a subcommittee consisting of John Helmberger (chairman), Oscar Hoffman, and Les Manderscheid.

The Committee recommends that a 2½-day workshop on education be sponsored by AAEA at Gainesville, Florida, in connection with the 1972 annual meeting. The main objective of the workshop would be to consider relevant content of agricultural economics educational programs. Other items to be considered would include educational goals, the market for agricultural economists, guidelines for curriculum changes, and improvement in teaching performance. A copy of the proposed program, showing first-choice speakers, is attached. A list of alternate speakers has been developed.

If approved by the President and the Program Committee, the opening session of the workshop would be held on Wednesday forenoon, and all members attending the annual meeting would be encouraged to attend it. Attendance at subsequent sessions would be limited; the workshop would adjourn at noon on Friday.

The Committee suggests that attendance at the workshop be open to any member of the Association.

Special invitations to resource people would be issued from lists obtained from department chairmen and from the Industry Committee. An attendance of 60–75 would be anticipated.

A registration fee of $25 would be charged each person attending, except outside speakers. All costs of conducting the workshop, including mailings and outside speakers, would be covered by the registration fees. The Committee recommends that proceedings of the workshop be published as a supplement to *AJAE* and distributed to all members, with the cost to be borne by the Association. Assuming proceedings of 50 printed pages at 1971 prices as estimated by Editor Fuller, the cost to the Association would be approximately $3,000.

JAMES NIELSON, *Chairman*

REPORT OF THE EXTENSION AFFAIRS COMMITTEE

Extension awards program criteria. The Extension Affairs Committee has been the frequent recipient of expressions of confusion and uncertainty regarding the criteria for the Extension Program Award. It is the unanimous opinion of the members of the Extension Affairs Committee that if the award is continued the extension program award criteria should be revised.

The Extension Affairs Committee has undertaken a suggested rewrite of the criteria. This rewrite has been forwarded to the Awards Committee for their consideration. In general the Extension Affairs Committee favors placing more emphasis on an extension *program* in economics and less emphasis on the individual.

Joint meeting with the Extension Awards Committee. The Extension Affairs Committee recommends that a joint meeting with the Extension Awards Committee be held as soon as possible after the 1972 committee members are appointed. The meeting would focus on the rewrite of the extension program award criteria, with the presentation of a more precise statement as the objective.

In addition, several questions regarding the new extension publications award should be resolved at the proposed joint meeting.

Association Program Committee. The Extension Affairs Committee urges the establishment of an annual meeting program committee as a part of the Association's committee structure, believing that the program responsibility is too great a burden to be carried by the president in addition to his other responsibilities. The president-elect should be considered as a possible program committee chairman.

Meeting topic resolution. The Extension Affairs Committee recorded the following resolution:

Resolved: We believe revenue sharing as it relates to financing local governments is a very important topic to explore as a nationwide Extension educational effort and as a program topic for the 1972 AAEA annual meeting.

Extension exhibits at annual meetings. The Extension Affairs Committee received the suggestion that several states be requested to establish extension program exhibits at a prominent location during the annual meetings. These exhibits were to be prepared with the objectives of promoting economics extension and improving communications between extension, research, and teaching.

The committee believed that the results of such exhibits would not warrant the effort necessary to prepare an impressive exhibit. The proposal was rejected.

Proposal for circulation of extension materials. The committee received a proposal that a circulation system be established to improve communication among states. With this system the farm management specialists would circulate effective program materials with other farm management specialists; marketing specialists and others would engage in similar circulation of materials.

The committee recognized the need for improved communication and the necessity of continued effort. However, the suggestion was rejected as a project of the Extension Affairs Committee. The committee recommends that materials and program ideas be shared in connection with established meetings, especially regional meetings.

Future committee work. The 1971 Extension Affairs Committee suggests the following topics to receive attention of future committees.

1. Extension assistantship policies, types, and amounts.
2. What is the appropriate role of an extension economist that would permit him to become actively involved in programs like community resource development—and also maintain professional integrity and professional advancement?
3. Is there merit in a regional extension pilot project in community resource development that would involve several states?
4. What is the basis for political support for extension social science programs?
5. Should extension economists be on part-time research appointment in order to have a research base for extension work in economics?

EBER ELDRIDGE, *Chairman*

REPORT OF THE MEMBERSHIP COMMITTEE

The structure of the Membership Committee was completely revised this year. Dividing the responsibility by regions had not really worked. The chairman decided to handle all correspondence to the universities and colleges and to the government agencies directly. The only other member of the committee this year was Neill Schaller, and he was asked to make contacts with members of industry. The Secretary-Treasurer, John C. Redman, did a tremendous job in contacting current members and working with delinquent members.

A notice of the 1971 dues was sent out with the information on the Winter Meetings. In the November issue of the JOURNAL, a card was inserted reminding members of their dues and facilitating their submission. In February a notice was mailed to all members who had not paid their dues. In April a second notice was sent to delinquent members, warning them that they would be taken off the rolls and that they would not receive their ballots for the election nor the form for the new directory. Still a third notice was sent in July to members whose names had been taken off the rolls this year. This was sent through the membership representative at the respective institution.

There was a special effort made to reenlist those members who did not pay at all in 1970. In January 1971 the Secretary-Treasurer sent a letter to each of these delinquent members. Good response was received, and many even paid their back dues.

In January the chairman wrote a letter to the heads of the agricultural economics departments of all land-grant universities, to the deans of other colleges or universities giving courses in agriculture (including the "1890" colleges), and to the directors and administrators of all federal agencies employing agricultural economists. They were asked to designate a membership representative for their institution to work with him in recruiting new members and to remind current members to send in their renewal. Excellent cooperation was received, with replies coming from most of the institutions. Many chairmen agreed to take this responsibility themselves.

In February these membership representatives were asked to contact their colleagues, including graduate students, and to submit the number who were members or not members. Many put notices in annual news notes and engaged in other activities to increase membership in their organization. Since there had been considerable falloff in library subscription following the increase in rates, they were also asked to contact the libraries and make sure they were subscribing to the JOURNAL.

The results of the survey of membership was compiled and sent back to each of the membership representatives in June. They were advised that the third notice of delinquents would be sent to them so that they could make personal contact.

The efforts of the committee and the Secretary-Treasurer, plus the interest in the new Handbook, have combined to make the renewal rate much better this year than previously. Between January and July of 1970 there was a falloff of 1,123 members and subscribers. This year there is a falloff of only 460 members and subscribers. It is expected that many will still join and that our total membership will surpass the record established in 1969.

Our regular membership has held up fairly well. Much of the problem is with junior and foreign members. There are 266 out of 618 foreign members delinquent so far this year, whereas there are only 63 out of 2,676 regular members delinquent. (Of course, new memberships are included in this global figure.)

QUENTIN M. WEST, *Chairman*

REPORT OF THE INTERNATIONAL COMMITTEE

The coordination of the activities of the committee has been severely limited in the last six to nine months by the restrictions on out-of-state travel imposed by a number of institutions. It did not prove possible to organize a meeting of the full committee. However, the chairman and members of the committee have engaged in a variety of activities of interest to the Association. Most important among these activities has been the very close coordination achieved between the Technical Assistance Bureau (TAB) of AID and the Association, on the one hand, and between the Agricultural Development Council (ADC) and the AAEA, on the other.

TAB-AID has continued to work closely with members of the Association. Four 211d institutional grants were made to further research, teaching, and advisory functions, especially in the area of agricultural development, at Cornell, Iowa State, Michigan State, and the University of Minnesota. In addition, a number of specific country and regional research contracts dealing with many aspects of development were entered into between AID and various universities.

TAB is presently setting up a panel of experienced agricultural development economists who might be potentially available for both short-term and long-term assignments abroad. The list of panel members is to be circulated among AID field missions abroad, which in turn will make specific requests. TAB is also preparing selected bibliographies in topics such as sector analysis, with the help of members of the Association. It should be noted that Arthur Coutu and Larry Witt have been extremely valuable in establishing a large number of bridges between AID and the AAEA.

ADC started a Research Training Network about a year ago under an AID grant. Wayne Schutjer was appointed to supervise these activities on behalf of ADC. Schutjer worked closely with members of the International Committee in organizing a series of seminars, workshops, and conferences covering a wide variety of topics such as employment, income distribution, agricultural sector analysis and planning, agricultural trade policies and development, agricultural problems in developing countries, and the organization and financing of agricultural research. Among the many seminars which were held in the last nine months it might be worthwhile mentioning (a) the Workshop on Employment and Income Distribution, organized by Carl Eicher at MSU and held in December 1970 with the participation of about 40 agricultural economists from universities, government agencies, and foundations here and abroad; and (b) the conference on Agricultural Sector Analysis and Planning organized by Erik Thorbecke and held

at Iowa State in May of this year. A unique feature of that conference was the conscious effort to bring together economists involved in quantitative sector analysis of specific countries and regions in the developing world, on the one hand, and users and potential users of sector analyses from bilateral and multilateral agencies (e.g., AID, IBRD, OAS, FAO), on the other hand.

Finally, one ongoing activity which should be mentioned is the continuing effort of gathering a list of foreign visiting agricultural economists.

It is hoped that funds will be found to finance the travel expenses to hold a meeting of the full committee this Fall.

ERIK THORBECKE, *Chairman*

REPORT OF THE PROGRAM STUDY COMMITTEE

The committee reported to the AAEA Executive Board meeting in December 1970 (Detroit) the need to broaden the program-planning base to more fully represent the diverse interests and geographic elements in the Association. The committee recommended that the AAEA president or president-elect serve as chairman and member of the program committee and that the Board of Directors comprise the remainder of the program committee. This structure was suggested not only to broaden the planning base, but also to minimize the need for additional bureaucracy, travel expense, and elections.

The motion was moved, seconded, and passed that the directors and the president constitute the program committee, with the president serving as chairman. The program committee normally will meet at the end of the summer meeting to establish the program format, theme, and a tentative list of topics for the meeting the following summer. After the program format and theme are established, these will be sent to the agricultural economics department heads and directors throughout the country for their suggestions concerning topics to be presented and people to present them. At the winter meeting the program committee will again meet to firm up the organization of the program, including a list of participants. There will of necessity be some intermeeting communication among members of the program committee.

The president as chairman shall be responsible for carrying out plans made by the program committee. He is empowered to make changes to fill omissions, replace refusals and dropouts, avoid duplication, and to take such action as necessary to finalize the program.

The president shall be solely responsible for the first general session of the annual summer meeting and for selecting the individual to present the Fellows lecture. Because of scheduling problems and the need to coordinate with the allied social science associations, the president of the AAEA is expected to take major initiative in planning and expediting the winter program. To the extent feasible, however, he should coordinate plans with other members of the program committee.

Since the by-laws can be amended by the Executive Board, no further action by the Executive Board or by the Association in its general business meeting is necessary at this time. However, the bylaws should reflect the Detroit action. In the simplest form, this requires a change in Article VI, Section 1. It now reads, "He [the president] shall be responsible for preparing a program for the annual meeting." In revised form it would read, "He [the president] and the Board of Directors shall comprise the program committee. The president is chairman of the program committee which shall be responsible for preparing a program for the annual meeting."

LUTHER TWEETEN, *Chairman*

REPORT OF FELLOWS ELECTION COMMITTEE

From among six nominees received from the Board of Directors, the Committee elected D. Howard Doane, Don Paarlberg, and Rainer Schickele to be made Fellows of the American Agricultural Economics Association at the annual meeting in August 1971.

G. E. BRANDOW, *Chairman*

REPORT OF TELLERS COMMITTEE

Ballots received from the Secretary-Treasurer were counted by the Tellers Committee in the manner prescribed by the bylaws to preserve the secrecy of the ballots. Emery N. Castle received a majority of the votes cast for President-Elect. Lee M. Day and Luther T. Wallace received a majority of the votes cast for Director in their respective categories.

A. FRANK BORDEAUX, JR.
BRUCE R. BEATTIE

ASSOCIATION NAME CHANGE PREFERENCE POLL (Final Count)

Prefer a Name Change	393
Oppose a Name Change	1046

Names suggested by those indicating a preference for change:

Agricultural and Applied Economics Association *or* American Agricultural and Applied Economics Association	292
Applied Economics Association *or* American Applied Economics Association *or* American Association of Applied Economics	49
Agricultural and Resource Economics Association *or* Agricultural and Natural Resource Economics Association *or* Natural Resource Economics Association	7
American Farm Economics Association	7

American Agribusiness Association	,5
American Rural Economics Association	5
Others	11
Total	393

MINUTES OF THE EXECUTIVE BOARD MEETING

Detroit, Michigan, December 27, 1970

The meeting was called to order by President Jimmye S. Hillman at 8:35 a.m.

Present:

Voting members: Hillman, Hathaway, McKee, Sundquist, Toussaint, Dunbar, Hildreth, Tweeten
Members ex officio: Redman, Wyckoff
Guests: Jones, Day, Polopolus

1. Jones reported on local arrangements.
2. Hathaway moved that the agenda as proposed be adopted. Seconded. Passed.
3. Redman presented the minutes of the meeting of the Executive Board held at Columbia, Missouri, on August 8–9, 1970. Hathaway moved to adopt the minutes as previously distributed. Seconded. Passed.
4. Hildreth moved that the Secretary-Treasurer send ballots for officers to foreign members on "areograms" with appropriate instructions and report back the results of the experience. Seconded. Passed.
5. McKinsey presented the final report on the arrangements for the 1970 meeting held at Columbia, Missouri. Toussaint moved that the report, and particularly the recommendation that any remaining funds left from the meeting be transferred to the University of Missouri as a partial payment toward the cost of liability insurance which was provided, be accepted and the books closed. Seconded. Passed.
6. Hathaway reported on progress of establishing Employment Service. Noting that the Employment Service and the Awards Program are functions of the AAEA and that costs should not be borne by host institutions, Toussaint moved that the cost of these activities be made a part of the budget of AAEA and that the chairmen of these activities be responsible for preparation of budgets and brochures. Seconded. Passed.
7. Hillman reported on his activities as president, stating that committees have been appointed and that the list will appear in May issue of the JOURNAL.
8. Dunbar moved that the Fellows breakfast be dropped as a part of the official program. Seconded. Passed.
9. Hillman presented a request from the American Society of Agronomy that a member of AAEA be appointed to serve as a liaison. Tweeten moved that Ray Hoglund be appointed. Seconded. Passed.
10. Hillman presented an expression from the American Society of Agronomy for cooperation with AAEA in developing an Environmental Quality Directory for Agricultural Sciences. After discussion, the request was referred to the Professional Activities Committee.
11. Toussaint moved that AAEA support the general objectives of the American Society of Agronomy with respect to the American Association for Advancement of Science and refer the details to the Professional Activities Committee. Seconded. Passed.
12. Day reported for the Advisory Board for the Bibliography and discussed the nature of problems encountered. After discussion of the publication alternatives Tweeten moved that AAEA print 1,000 copies of the first volume and that the Advisory Board and the Secretary-Treasurer determine the distribution of these copies, which are to be free to recipients. Seconded. Passed.
13. Hathaway moved to authorize the Secretary-Treasurer to refund the subscriptions already paid for the Bibliography and to pay the necessary expenses incurred with the printing of 1,000 copies.
14. Martin reported for the Postwar Review Committee.

Meeting recessed at 12:30 p.m. and reconvened at 2:30 p.m.

Present:

Voting members: Hillman, Hathaway, McKee, Sundquist, Toussaint, Dunbar, Hildreth, Tweeten, Ruttan
Members ex officio: Redman, Wyckhoff
Guests: Day, Polopolus, Manderscheid, Bonnen, Wills

15. Manderscheid reported for the Education Committee. Hathaway moved that the Education Committee meet at their own expense to plan a workshop to be held in 1972. Seconded. Passed.
16. Bonnen reported for the Statistics Committee.
17. Wills reported on arrangements for the 1971 Summer Meeting to be held at Carbondale. McKee moved that the budget as presented be approved in general and that the registration fees be set at $12.00 for single registrants and $18.00 for those with families. Seconded. Passed.
18. Polopolus, the incoming editor, reviewed the editorial objectives and policy for the JOURNAL.
19. Hildreth reported, in part, on the role of AAEA to related areas of activities.
20. Ruttan reported on request from forestry economists for scheduling joint sessions with AAEA in 1971.

21. Wyckoff, as president of New England Agricultural Economics Council, an ex officio member of the Executive Board, reported that his group felt the regional association presidents should be made full voting members of the Executive Board.
22. Tweeten reported for Program Planning Committee and recommended that in order to broaden the base for program planning, a committee be appointed with the president-elect as chairman. Dunbar moved that the Executive Board meet for an extra session at the end of the Summer Meeting for the purpose of evaluating and planning the program for the next Summer Meeting and that the president present a suggested program format and topics for consideration. Seconded. Passed. Tweeten moved that the Board of Directors constitute the program committee with the president serving as chairman. Seconded. Passed.
23. Tweeten presented a national constitution of the Student Section of AAEA. Hildreth moved that the constitution be approved in principle and that the details be worked out and presented at the next Board meeting. Seconded. Passed.
24. Tweeten presented the request for increased budget for the Student Section. Tweeten moved that the proposed budget be approved. Seconded. Passed.
25. Hathaway suggested that the president-elect consider an appropriate number of students to be added to the committees on selecting the recipients of awards.
26. Hildreth presented a report from the Professional Activities Committee recommending a change of name of AAEA to encompass the word "Applied." Hathaway moved that the sentiments of the membership be obtained. Seconded. Passed.
27. Redman reported for the Handbook Committee.
28. Redman raised the question of meeting places for future meetings. Meeting adjourned at 6:30 p.m.

Respectfully submitted,
JOHN C. REDMAN, *Secretary-Treasurer*

MINUTES OF THE EXECUTIVE BOARD MEETING

Carbondale, Illinois, August 14-15, 1971

The meeting was called to order by President Jimmye Hillman at 9:00 a.m. August 14, 1971.

Present:

Voting members: Hillman, Toussaint, Sundquist, Ruttan, Hildreth, Tweeten, McKee, Dunbar, Hathaway
Members ex officio: Redman, Plaunt, Christensen
Guests: Wills, Day, Castle, Abel

1. Minutes of Winter Meeting of the Executive Board Meeting at Detroit on December 27, 1970 were approved as distributed.
2. Wills reported for the Local Arrangements Committee. He indicated that about 800 members had registered. Also, he questioned the feasibility of mailing out the papers in advance because of the logistics and mail service.
3. Redman distributed the Secretary-Treasurer's annual report and Investment Committee's report, which will be presented to the members at the general business session.
4. Redman reported for the Tellers Committee that Castle was elected as president-elect, and Wallace and Day were elected as Board members. Dunbar moved the acceptance. Seconded. Passed.
5. The Audit Committee's report was read by Redman. Hildreth moved the acceptance. Seconded Passed.
6. Redman presented the contract proposal with George Banta Company for printing the JOURNAL. The contract called for approximately 20 percent increase over 1971. After discussion Dunbar moved that the Banta contract be accepted and the Secretary-Treasurer sign the contract on behalf of the Association. Seconded. Passed.
7. After discussion on the cost of postage on returned JOURNALS and on remailing the JOURNAL, Toussaint moved to authorize the Secretary-Treasurer to assess a $1.00 service charge for postage and handling. Seconded. Passed.
8. Dunbar moved that the student rate, presently limited to maximum of three years, be continued as is. Seconded. Passed.
9. Redman raised the problem of apparent necessity of increasing the student rate to 50 percent of the regular rate, which is apparently required to qualify for continued use of the second class postage permit. Hildreth moved that the Secretary-Treasurer check with Dr. Neil Harl for his opinion and to explore alternatives, such as $7.50 for four years, and report back at next Board meeting. Seconded. Passed.
10. Question arose whether the AAEA still had the life membership available. At the present time only two are life members. Tweeten moved that the opportunity for life membership be dropped. Seconded. Passed.
11. Redman reported that J. S. Canner and Company plans to reprint the first ten volumes of the JOURNAL, with a royalty payable to the AAEA.
12. Hathaway moved that the AAEA accept the invitation of the Pennsylvania State to host the Annual Meeting in August 1976. Seconded. Passed.
13. The expense of postage and handling back copies for members who are delinquent in payment of dues was discussed. Dunbar moved that members who pay their dues too late to be kept on

the mailing list be added effective with the next issue after payment and that no back issues be ordered. For new members the back issues will be ordered. Seconded. Passed.

14. Redman reported for the Directory-Handbook Committee. Forms have been sent and the return has been good. Hathaway suggested that an SOS be sent to the Department chairmen to give new graduate students an opportunity to be listed.
15. Ruttan reported on program for the Winter Meeting in New Orleans. Also suggested that the AAEA may have an excessive number of committees.
16. Question arose concerning the grammar of the word "Economics" in the name of AAEA. Dunbar suggested that the question be dropped.
17. Tweeten reported on the committee structure of the AAEA with respect to the "power structure," recommending that the president appoint a committee that will include a past president to study the committee structure, the representativeness, etc. Seconded. Passed.
18. Day reported for the Bibliography Committee, indicating that the University of Kentucky Printing Department had the lowest bid for printing. Alternative ways of distribution and rates were discussed. Ruttan moved that the subscription rate be set at $10.00 per year, that single copies be $3.00 for all libraries and members, and that the committee be authorized to implement this activity. Seconded. Passed.

Meeting recessed at 12:15 p.m.
Meeting reconvened at 1:30 p.m.

Present:

Voting members: Hillman, Toussaint, Sundquist, Ruttan, Hildreth, Tweeten, McKee, Dunbar, Hathaway
Members ex officio: Redman, Plaunt, Christensen
Guests: Day, Castle, Polopolus, Baker, Mutti

19. Hildreth reported for the Professional Activities Committee. With respect to visiting lecture program, Tweeten moved that this part of the report be accepted with thanks. Seconded. Passed.
20. With reference to the Professional Activities Committee report, Toussaint moved that the Awards Committee make an evaluative study of the awards program, with the view of seeking an improvement in the achievements in relation to cost, and report by next August. Seconded. Passed.
21. Concerning the supply and demand aspects of agricultural economists, Toussaint moved that the incoming president appoint an ad hoc committee to study the problem and to coordinate their activities with those of the Education Committee. Seconded. Passed.
22. Hildreth moved that the issue of hiring an executive secretary be dropped for the next few years, or until the financial position of AAEA can clearly justify the action. Seconded. Passed.
23. Christensen reported on behalf of the New England Agricultural Economics Council which recommended that NEAEC and other regional associations be granted full voting membership on the Executive Board of AAEA. He also recommended that the family activities of the Annual Meeting be reduced or eliminated because the universities in the Northeast could not be privileged to host the AAEA because of size. No action was taken.
24. After a discussion on the issue of a name change, Tweeten moved that the president commission a person to prepare a paper and/or inform the membership through the JOURNAL or newsletter on the issues of a name change. Seconded. Passed.
25. Hildreth agreed to present a summary of the discussion on the issue of name change to the general membership at the business session.
26. Baker reported for the Awards Committee. He announced that the teaching award was divided on basis of number of years in teaching.
27. Mutti reported for the Brochure Committee. A discussion followed on revision of certain portions of the mock-up, costs of printing, etc. Toussaint moved that AAEA print 30,000 copies by any method the committee selects and sell on cost basis. Seconded. Passed.
The committee turned the finished product over to Redman to assume the responsibility of printing and selling.
28. Toussaint moved that the Editorial Board study the feasibility of initiating a page charge for the Journal and report to the Board next year. Seconded. Hathaway moved an amendment that should a page charge prove to be feasible, the issue be presented to the membership as an alternative to a dues increase. Seconded. Passed. Original motion as amended passed.

Meeting adjourned at 5:15 p.m.

The meeting was called to order by President Hillman at 9:05 a.m. August 15, 1971.

Present:

Voting members: Hillman, Toussaint, Sundquist, Ruttan, Hildreth, Tweeten, McKee, Dunbar, Hathaway
Members ex officio: Redman, Plaunt, Christensen, Carter (substituting for Fuller)
Guests: Day, Castle, Polopolus, Nielson, Sjo, Helmburger, Mather, Jensen, Erickson

29. Neilson reported for the Committee on Education.
30. With reference to the report by the Committee on Education, Dunbar moved that the Committee conduct an annual survey of information on

curriculum changes in agricultural economics and make the information available. Seconded. Passed.

31. Toussaint moved that the Committee on Education of the AAEA initiate and plan a two and half-day workshop to hold in conjunction with the Annual Meeting in Florida next August. Seconded. Passed.
32. Dunbar moved that the Committee on Education be authorized to publish the proceedings of the workshop in JOURNAL format, that it be edited to 50 pages and that the editor explore the alternatives of publication and establish the price of extra copies. Seconded. Passed.
33. Mather and Hathaway reported for the Employment Committee. On the possibility of study the employment of professionals, it was agreed that efforts be continued to obtain funds for the study.
34. Sjo reported for the Student Affairs Committee, presenting several items for consideration.
35. Tweeten moved that the suggested revision of the SS-AAEA Constitution be approved. Seconded. Passed.
36. Hildreth moved that the budget request be approved. This allows \$600 for awards, \$300 for judges, \$150 for newsletter, \$70 for plaques, keys, etc. and \$20 for printing and miscellaneous, or \$1,140 total. Seconded. Passed.
37. With respect to establishing an award for the best chapter, Hildreth moved that the Student Affairs Committee and officers study the role of the Student Section and the Student Affairs Awards and coordinate their study with the overall study of the awards program. Seconded. Passed.
38. Redman reported on some problems of receiving stale checks from student chapters and of evaluating the authorization of expenditure requests. It was agreed that the chairman of the Student Affairs Committee would approve all expenditure requests.
39. Erickson reported for the Industry Committee on plans and activities that will contribute to the educational needs of the profession.
40. Dunbar summarized the report for the Extension Affairs Committee. Among the items mentioned was the concern with the criteria for selection of awards.
41. With reference to the Handbook-Directory, Toussaint moved that when the next Handbook-Directory is published a serious study be made of the classification of the fields of interest. Seconded. Passed.

Meeting recessed at 12:10 p.m.
Meeting reconvened at 1:45 p.m.

Present:

Voting members: Hillman, Toussaint, Sundquist, Ruttan, Hildreth, Tweeten, McKee, Dunbar, Hathaway

Members ex officio: Redman, Plaunt, Christensen

Guests: Polopolus, Day, Castle, West, Brandow, Martin, Pearson, Halcrow

42. West reported for the membership committee, suggesting ways to be explored to increase the membership. The committee concentrated on attracting new members while the Secretary-Treasurer concentrated on keeping the membership by dues notices, letters, etc.
43. Kearl, unable to be present, sent the Sustaining Membership Committee report, which was distributed.
44. Brandow reported as the representative to the National Research Council. Among the activities reported was the plan to organize a Council of Agricultural Sciences. Tweeten moved that the AAEA maintain a liaison with the Council but at this time not become affiliated. Seconded. Passed.
45. Martin reported for the Literature Review Committee, indicating the nature of progress of writing the review articles. Some concern was expressed regarding the slowness of the forthcoming product.
46. Thorbecke sent a written report for the International Committee.
47. Hildreth reported for the Economic Statistics Committee.
48. Hathaway moved that, should it become necessary, the Secretary-Treasurer be authorized to make a decision with respect to the 1975 annual meeting which is being invited to come to Miami Beach. Seconded. Passed.
49. Halcrow reported as AAEA representative to the National Bureau of Economic Research.
50. Redman presented the budget for 1972. After discussion and adjustments were made, Dunbar moved the approval. Seconded. Passed.
51. Pearson reported on the plans for the 1972 Annual Meeting which will be held on the campus of the University of Florida on August 20–23, 1972.
52. Dunbar moved that \$2,000 be advanced on a loan basis to the University of Florida for the Annual Meeting. Seconded. Passed.

Meeting adjourned at 4:19 p.m.

Respectfully submitted,
JOHN C. REDMAN, *Secretary-Treasurer*

MINUTES OF THE ANNUAL BUSINESS MEETING

Carbondale, Illinois, August 18, 1971

Meeting was called to order by President Hillman at 8:35 a.m.

1. President Hillman presented for approval the

minutes of the Annual Business Meeting held in Columbia, Missouri, August 20, 1970, as published in the Proceedings issue of the AJAE. Nielson moved approval. Seconded. Passed.

2. Hillman reported on the Board's consideration of the alternative methods of selecting the president of AAEA, which was referred last year to the Board for study. For the time being no better alternative has been found.
3. Redman presented the Secretary-Treasurer's report for the fiscal year January 1 through December 31, 1970.
4. Redman presented the Investment Committee report for the fiscal year January 1 through December 31, 1970.
5. Redman presented the report for the Audit Committee for the fiscal year January 1 through December 31, 1970.
6. Polopolus reported on policy and procedures that will be followed as the incoming editor.
7. Hillman summarized the actions of the Executive Board. These include: (1) approved a new policy on late payment of dues—those paying after April 1 will receive the Journal effective with the next issue but new members will receive back issues to cover the entire year; (2) voted to establish an ad hoc committee to study the overall committee structure of AAEA; (3) reported that the first issue of the American Bibliography is in press at the University of Kentucky, distribution of which will be made to departments and libraries of the United States and foreign countries free of charge for 1971, and effective 1972, it will be available only by subscription at $10.00 per year; (4) voted to ask the Awards Committee to evaluate the awards program in terms of benefits and costs; (5) voted to appoint an ad hoc committee to study the supply and demand for agricultural economists; (6) considered the vote and the issues involved with a name change (Hildreth was asked to summarize the discussion by the Board); (7) decided to print 30,000 copies of the brochure which will be purchased and distributed by departments; (8) asked the Editorial Board to study the feasibility of a page charge for the Journal and report back next August, and should a page charge prove feasible the membership would be given the alternative of a page charge or dues increase; (9) voted to drop the idea of an executive secretary for the immediate future or until the financial condition of the association improves; (10) approved the 1972 contract with George Banta Company which calls for about 20 percent increase over 1971, or about 24 percent increase over 1970; (11) voted to sponsor a 2½-day workshop on teaching of economics at Gainesville, Florida, after the 1972 meeting; (12) voted to maintain liaison with the Council of Agricultural Sciences but not at this time become affiliated.
8. Carter moved that the issue of copyrighting the Journal be studied again. Seconded. Passed.
9. Carter reported on the activities of the editor and his staff.
10. Redman presented a budget for 1972 for consideration. Upchurch moved that the budget be approved. Seconded. Passed.
11. Trelogan offered the following Resolution: "Be it resolved that the AAEA thank the University of California for providing the services for the Editor of the Journal and that a special thanks to Varden Fuller, Harold Carter, Gerald Dean and Miriam Revzan for a splendid job as editors. Also, to Allen Paul of the Economic Research Service the Association expresses its deepest appreciation for serving as Book Review Editor." Seconded. Passed.
12. Castle presented a Resolution thanking the Southern Illinois University for hosting the meeting, with copies to be sent to the appropriate personnel. Seconded. Passed.
13. With no further business, Hillman thanked the membership for the privilege of serving as president, noted good attendance in light of travel difficulties and budget cuts, noted that the Association was in good shape despite the problems, and turned the meeting over to incoming President Ruttan. Ruttan announced the nominating committee, the dates of December 27–29, 1971 for the Winter Meeting in New Orleans and August 20–23, 1972, for the next Annual Meeting, suggested that nominations for Fellows be in the hands of the Secretary-Treasurer before the Winter Meeting.

Meeting adjourned at 10:00 a.m.

Respectfully submitted,
John C. Redman, *Secretary-Treasurer*

AAEA COMMITTEE STRUCTURE, 1970–1971

American Journal of Agricultural Economics

Varden Fuller, *Editor*
Harold O. Carter, *Associate Editor*
Gerald W. Dean, *Associate Editor*
Allen B. Paul, *Book Review Editor*

Editorial Council

Richard O. Been
John S. Bottum
W. Keith Bryant
Walter Butcher
Wilfred Candler
Peter Dorner
Walter P. Falcon
Donald E. Farris
Robert S. Firch
Wayne A. Fuller
Allen V. Kneese
John E. Lee
W. Neill Schaller
Ronald A. Schrimper
James Shaffer
Anthony M. Tang
Edward W. Tyrchniewicz

Awards Committee

Chester Baker, Chairman, Illinois, 1967

Distinguished Undergraduate Teacher Award

John Malone, Jr., Chairman, Nevada, 1968
John Timmons, Iowa State, 1968
Milton Snodgrass, California Polytechnic, 1969
Jack Thompson, Georgia, 1970
David K. Armstrong, Michigan State, 1970
Bob Christensen, Massachusetts, 1970
John Neal, Texas A&M (student)

Extension Award

Gene McMurtry, Chairman, Virginia Polytechnic, 1969
Charles Beer, FES, USDA, 1969
John Bottum, FES, USDA, 1970
Clarence Klingner, Missouri, 1968
Henry Meenan, Arkansas, 1970
Ray Penn, Wisconsin, 1969
Luther T. Wallace, California, Berkeley, 1970
Jean Wyckoff, Massachusetts, 1970

Published Research Award

J. O. Gerald, Chairman, ERS, USDA, 1969
Dale Knight, Kansas State, 1969
Bud Stanton, Cornell, 1969
Howard Williams, Ohio State, 1969
M. L. Lerohl, Ottawa, Ontario, 1969
Joseph Havlicek, Jr., Purdue, 1969
Bill Martin, Arizona, 1970
William Motes, EDD, ERS, USDA, 1970
Billy Lessley, Maryland, 1970
Walter Butcher, Washington State, 1970
Carlton Dennis, Agway Corporation, 1970
J. A. Seagraves, North Carolina State, 1970
Lee Bawden, Wisconsin, 1970

Master's Thesis Award

Eldon Weeks, Chairman, Washington State, 1967
Dale Anderson, North Dakota State, 1969
Wallace Rehberg, Washington State, 1970
Tom Hady, ERS, USDA, 1969
Leroy Quance, Oklahoma State, 1969
Jim Kendrick, Nebraska, 1969
Robert Rizek, ERS, USDA, 1969
David Allee, Cornell, 1970
Bob Herdt, Illinois, 1970
Tom Williams, Southern U., Louisiana, 1970
Jim Youde, Oregon State, 1970
Eric Oesterle, Purdue, 1970
Steven Lytle, Clemson, 1970

Ph.D. Dissertation Award

Willard Williams, Chairman, Texas Tech., 1967
Burl Back, USDA, 1969
Gail L. Cramer, Montana State, 1969
Joe Purcell, Georgia, 1969
Wayne Purcell, Oklahoma, 1969
Walt Miller, ERS, USDA, 1970
Fred Tyner, Florida, 1970
Verner G. Hurt, Mississippi, 1970
Frank Orazem, Kansas State, 1970
Don Farris, Texas A&M, 1970
Frank Smith, Minnesota, 1970
Hugh Cook, Wisconsin, 1970
Dan Bromley, Wisconsin, 1970
Royce Hinton, Illinois, 1970

Audit Committee

Fred E. Justus, Kentucky, 1970
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